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BOTTOM LOSS MEASUREMENTS IN THE EASTERN PACIFIC OCEAN (U)

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NAVAL AIR DEVELOPMENT CENTER
Warminster, Pennsylvania 18974

26 JANUARY 1977

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AIRTASK NO. A370370A/202B/F11-121-707

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) Low frequency acoustic bottom loss measurements were conducted from aircraft over a broad Northeastern Pacific region, using sonobuoys and explosives. Geologic descriptions of the region typify it as being somewhat uniformly blanketed by pelagic clays less than 100 m thick. Bottom loss at the 20 stations visited, however, showed considerable variation. Individual station results are presented with supporting data. In

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addition, bottom loss data acquired at several closely grouped stations north of Hawaii are compared to results of measurements conducted in the same region by shipboard techniques during the PARKA II-A exercise.

SUMMARY

INTRODUCTION

(U) Low frequency acoustic bottom loss measurements were conducted in the Northeast Pacific by the NAVAIRDEVCEN during April and May 1974, using sonobuoys and explosives deployed from an aircraft. The purpose of these measurements, sponsored under AIRTASK A370370A/202BF11-121-707, work unit ZU-101, was to add comparative data from a significant Pacific region to an existing data base composed primarily of North Atlantic loss measurements. In addition to measurements at a number of sites in the northeastern ocean region, others were made at several closely grouped stations north of Hawaii for the purpose of providing direct comparison to similar measurements made from research ships by NUSC, New London, during the PARKA (Pacific Acoustic Range, Kaneohe - Alaska) II-A exercise in 1969.

SUMMARY OF RESULTS

Pacific Basin Sites

(U) Twenty-one bottom loss measurement stations were distributed widely over the Northeast Pacific. Twenty of these were situated over a bottom composed of rather thinly layered (< 100 m thick) pelagic clay sediments. There are noticeable differences in details of the bottom loss characteristics among these stations, more than might be anticipated considering the apparent geologic uniformity of the region. However, there are also general similarities in the individual site characteristics, and a median representation for the region is markedly different than grouped data from numerous North Atlantic sites.

(U) The median Pacific region characteristic shows losses to be nearly constant in levels above 15 degrees, and gradually rolling off toward zero loss below this grazing angle. In some individual cases, no rolloff is apparent in data that extend as low as 3 degrees. Three stations exhibit a marked increase in loss at the very low angles. Another attribute of the regional bottom loss is that there is, on the average, only about a 2 dB increase in level from 100 to 500 Hz, and a 4 to 5 dB increase from 500 to 1600 Hz. Overall, losses above 15 degrees typically vary from 6 dB at 100 Hz to 12 dB at 1600 Hz.

(U) A similar representation of North Atlantic high loss data, which excludes abyssal plain stations and lacks stations over sediments as thin as those of the Pacific stations, shows quite different qualities. In the Atlantic group, losses are virtually constant and equal at all frequencies for angles above 50 degrees. Below 50 degrees, significant frequency and angular dependence develops. Low frequency losses, which are about 8 to 9 dB at angles above 50 degrees grazing, roll off below this angle, reaching a minimum of 1 to 2 dB near 20 degrees; high frequency median losses remain at 8 to 9 dB down to 10 degrees, and then show a rolloff. There is an approximately uniform dependence of loss levels on frequency between these two extremes.

PARKA Site

(U) Data were acquired from ten closely grouped stations north of Hawaii. The results from all but one station were very much alike. The causes of anomalies observed in the single exception are uncertain. The ensemble average of data from the ine similar stations matched published results from shipboard measurements conducted during the PARKA II-A exercise to within 2 dB. Compared to bottom loss results from the Northeast Pacific basin, losses at the PARKA site were slightly less at higher frequencies, with little apparent difference at lower frequencies.

CONCLUSIONS

(U) The region of the Nor ieast Pacific that has a bottom of thinly blanketed pelagic clays is a region of moderately high bottom losses. The general character of bottom loss throughout the region is reasonably consistent, and is noticeably different than the ensemble average of high loss measurements from extensive areas of the North Atlantic. Whereas the North Atlantic data show a grazing angle dependency below 50 degrees that varies greatly with frequency, Pacific losses indicate little angular dependency above 5 to 15 degrees, and a significant frequency dependence exists at all angles.

(U) It is believed that the general similarity of bottom loss characteristics obtained from the Pacific basin measurements, and the difference between these and high loss characteristics obtained from the North Atlantic, are related largely to thinness of sediment in the Pacific region. Others have shown, by theory and measurement, the potential for dependence of bottom loss on sediment thickness, and the NAVAIRDEVCEN measurements appear to bear this out.

(U) An average characterization of losses in this region of the Northeast Pacific, excluding a few instances of very high losses at low angles, shows constant losses above 15 degrees grazing, with a rolloff in loss at lower angles. The constant-loss levels vary from 6 dB at 100 Hz to 12 dB at 1600 Hz. There is better than a 50 percent probability that losses incurred at discrete sites will hold to within ± 2 dB of average characteristic values at angles as low as 5 degrees above 200 Hz, and to within ± 3 dB at lower frequencies.

(U) The origin of very high loss levels at low angles is uncertain, although it is clearly evident that considerable bottom path energy fails to reach the sensors in infrequent cases. The measurement of bottom losses becomes increasingly difficult, and the values more varied, as zero grazing is approached. It may be that there are errors in the propagation model (or inputs thereto) used in the extraction of bottom loss estimates, and that some losses attributed to the bottom should be traceable to other causes.

(U) There is no known geologic information that can be used to subdivide the Pacific basin into more exactly defined acoustic provinces. The available geologic data implies a general physical uniformity throughout the region. There are noticeable departures from the average bottom loss characterization in some of the individual site results, but without more thorough geologic or acoustic mapping, no better than an average characterization can be provided for the basin.

(U) The bottom loss measurement results obtained by the NAVAIRDEVCEN at the PARKA II-A site agree quite closely with previous NUSC results in spite of differences in measurement geometry, source level determination, processing bandwidth, and other details of measurement and processing.

RECOMMENDATIONS

(U) The characterization of regional bottom loss presented in this report should be viewed as an average empirical description for the Pacific basin within the bounds of thin pelagic sedimentation. The impact of local variations in losses or prediction of acoustic sensor system performance will have to be assessed by the potential user. If it is found that dispersion of loss values about the average characterization is too great to permit adequate prediction of some systems' performance capabilities and limitations, a more systematic regional mapping of geologic and/or acoustic properties of the region may be required.

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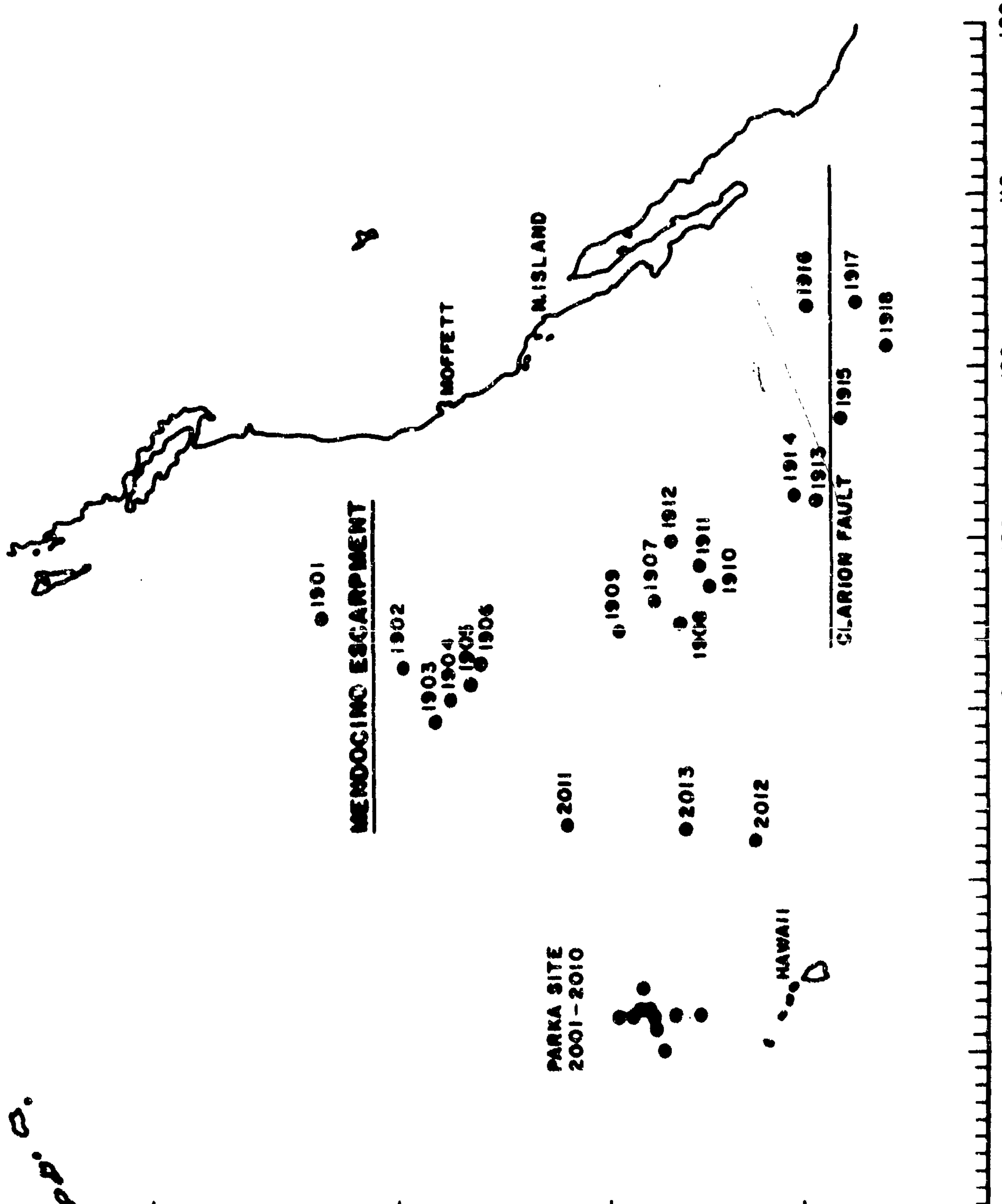
BACKGROUND

(U) Since April 1969, the NAVAIRDEVCEN has conducted an intermittent series of low frequency acoustic bottom loss measurements, using SUS explosives and sonobuoys launched from research aircraft. Begun as an investigation into suspected errors in the standard Navy model for low frequency bottom losses, and continued as a service to sensor development programs that required bottom loss data from various ocean locations, the program had amassed information from 129 North Atlantic stations by February 1974.

(C) In spite of its then appreciable content, the NAVAIRDEVCEN bottom loss data base lacked information about other regions of major size and importance. One region of tactical concern that is very unlike the Atlantic is the Northeast Pacific. The ocean bottom of most of the latter region is blanketed by a relatively thin layer of pelagic sediments[1, 2]. Measurements in thin sediment regions, made by other researchers, had revealed bottom loss characteristics noticeably unlike those found in areas with thick deposits of unconsolidated sediments, typical of most of the Atlantic[3]. In April 1974, the NAVAIRDEVCEN deployed a research aircraft to the west coast and in a series of flights, conducted measurements at 18 sites dispersed throughout an appreciable portion of the Northeast Pacific basin (stations 1901-1918), figure 1.

(U) From time to time, questions had been raised about the comparability of the NAVAIRDEVCEN's bottom loss results to those of other researchers because of differences in measurement and signal processing techniques. In discussions with the Director, AESD (Acoustic Environmental Support



(C) Figure 1 - Pacific Basin Measurement Stations. (U)

Detachment), ONR, it was suggested that the site of the PARKA II-A exercise might provide a means for checking compatibility of the NAVAIRDEVCEN's methods with those of NUSC, New London.

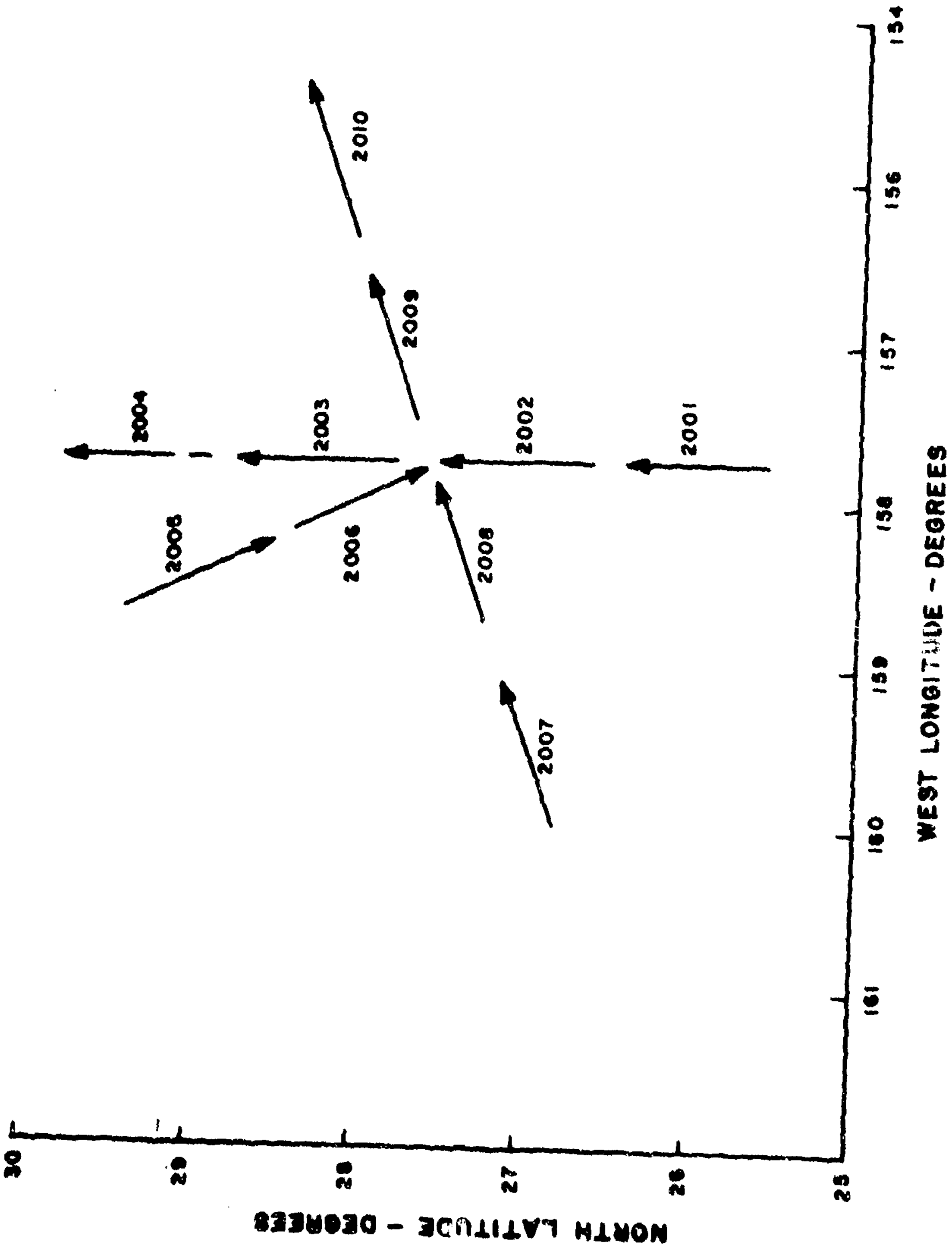
(C) During that 1969 exercise, NUSC conducted a series of bottom loss measurements north of Hawaii[4], using 3-pound TNT charges fired at 500 ft depth from a moving shooting ship, and a hydrophone suspended at 11,000 ft depth from a stationary receiving ship. The data were energy processed in 1/3-octave bands centered about 100, 180, 400, and 800 Hz. Shot source levels used in the analysis were extracted from direct path measurements. Central tendency of the data was estimated by polynomial curve fit.

(U) To obtain comparative data, the NAVAIRDEVCEN aircraft deployed to Hawaii in May 1974, and conducted measurements at 10 closely grouped stations (2001-2010) in the same ocean region, as indicated in figures 1 and 2. At this time, 3 more stations (2011-2013) were also visited in the northeastern basin. These are shown in figure 1.

DATA COLLECTION AND PROCESSING

(U) The methods used by the NAVAIRDEVCEN to conduct and process bottom loss measurements have been described in some detail previously[5], and so will be only briefly summarized here.

(U) Typically, 5 AN/SSQ-57A sonobuoys set for 300 ft (92 m), and 25 Mk 61-0 SUS set for 800 ft (244 m) are dropped at 30 s intervals from an aircraft as it makes a single pass over the measurement station at an altitude of 5000 ft and ground speed of 200 kn. The sonobuoys have reduced



(C) Figure 2 - PARKA Site Measurement Stations. (U) acoustic sensitivity to avoid saturation by the explosive signals. Source to receiver spacings are computed from altitude, ground speed, and launch interval data in conjunction with information on trajectories. Near-surface temperature profiles (0-300 m) are acquired via AXBT (airborne expendable bathythermograph) buoys during the acoustic measurement. These data are subsequently linked to historical deep profile data for the region, obtained from NODC (Naval Oceanographic Data Center), and the composite used to create a surface to bottom sound velocity profile. Bottom depths are obtained from bathymetric charts. Since these charts are constructed from acoustic soundings that assume a standard, constant sound speed, a simple corrective procedure is used to improve the ocean depth estimate, making use of the above mentioned sound velocity profile.

(U) The acoustic data, tape recorded via a calibrated system aboard the aircraft, typically represent measurement ranges from 4 kyd (3.7 km) to 100 kyd (91 km). The shot returns are first processed by a General Radio type 1921 (multi-channel, real-time, 1/3-octave) analyzer, covering the frequency spectrum from 27 to 2245 Hz. In subsequent processes involving a CDC-6600 computer:

1. individual shot returns are identified,

2. the total energy in each shot return is summed,

3. amplitudes are scaled to represent absolute acoustic energy levels, and

4. 1/3-octave bands are combined into octave bands to reduce sensitivity to scallops in the explosive's spectrum caused by the gas bubble.

The result is a set of received levels.

Bottom losses are then computed as:

$$BL = (SL - RL - SPL - 6)/n,$$

where:

BL = bottom loss

SL = source levels (energy flux density) from previously documented measurements,[6]

RL = received level (energy flux density)

SPL = spreading and attenuation losses derived from the sound velocity profile via a ray-trace program

n = number of bottom reflections (n = 1, 2, 3)

(U) The 6 dB is a correction factor necessary to convert the multipath measurement (bottom, surface-bottom, bottom-surface, surface-bottom-surface) to a single path estimate, based on an assumption that the four paths deliver equal energy.

(U) The acoustic signals are also examined on a high speed oscillograph to aid in the identification and separation of individual transmission paths, including bottom reflections, in-bottom refractions, and deep water-refractions.

RESULTS

Pacific Basin Sites

(U) Twenty stations, 1902-1918 and 2011-2013, are situated in the Northeas Pacific basin, over an extensive region of thin pelagic sediments. Estimated sediment depth at all of these sites is no more than 100 m. One site, 1901, is located in Tuft's Abyssal Plain, in a region of turbidites.

(U) The individual station bottom loss results are presented in figures 3 through 23. In each figure, bottom losses for four representative octaves spanning the analysis frequency range are plotted as a function of grazing angle. The "curves" are line segments connecting median bottom loss estimates that represent data grouped in the following manner and plotted at the center of each angular interval.

Grazing Angle Range (degrees)	Angular Intervals (degrees)
0 - 20	2.5
20 - 40	5.0
40 - 80	10.0

(U) Associated with each station bottom loss plot is a table (tables I through XXI) that identifies the site location, describes documented physiographic features of the local region, and presents individual comments about the site results. Ocean depths were obtained from Naval Oceanographic charts compiled by Scripps Institute of Oceanography[7]. Sediment thickness estimates are after Ewing's charting of two-way acoustic travel time in sediment[2], assuming a nominal in-sediment speed of 2 km/s. Bottom sediment type is from charts compiled by Scripps[1]. Available charts indicate the existence of many core samples taken in the Pacific, but relatively few have been described, documented, and made available to the oceanographic community. The core information used in this document is from a report by Lamont[8].

(U) Bottom loss characteristics from few of the sites could be termed "alike" in spite of the general uniformity of ocean bottom composition. In somewhat more general terms, however, similarities are to be found. With the exception of station 1901, which is known to reside in a region of greatly different geologic nature, all of the sites exhibit a tendency toward constant loss levels at grazing angles steeper than about 5 to 15 degrees. Individual departures from uniform losses at angles above 30 to 40 degrees can probably be ignored on the basis that the bottom bounce path is of little concern at short propagation ranges.

(U) It can be seen that, on the whole, losses tend to rise at an ever increasing rate as frequency increases. There is much site-to-site variation in this relationship, however; in several instances there is virtually no change in loss up to 500 Hz, at which point a substantial rate of increase starts, while in a few data sets, the increase with frequency is closer to uniform across the investigated band.

(U) Below 15 degrees, the losses at 17 stations either remain fairly uniform in level or break toward zero loss at some angle. It is possible, in fact probable, that in the instances where no significant decrease is apparent, the loss levels do diminish, but at angles below the limit of the measurement data.

(U) Three stations (1905, 1907, and 1917) exhibit pronounced increases in loss as grazing angle decreases below 10 degrees. It is possible that the losses reach maximums at some low angle, and then return toward zero loss, but no turn-around points are evident in the valid data, which are limited to angles above 2.5 degrees. At one site, rays returning from lower grazing angles did not reach the hydrophone depth because of downward refraction. At the other two sites, a significant depth excess caused the low angle bottom return energy to be contaminated by water refracted energy.

(U) Figures 24 through 28 are the result of grouping all the bottom loss data for the 17 stations that did not show an increase in loss at low angles. Each plot set represents 1 octave of data. In each set, the upper graph displays bottom loss as a function of grazing angle for various percentile levels. Starting at the lowest curve, the percentile levels shown are the 5th, 10th, 25th, 50th (median [dashed]), 75th, 90th, and 95th. The data have been grouped in angular intervals as previously described. The lower graph displays percentage of data contained within various constant-dB bands centered about the median loss values. Starting at the lowest curve, the bands represented are ±0.5, ±1.0, ±1.5, ±2.0, ±3.0, and ±6.0 dB.

(U) The bottom loss graphs show:

1. rather constant median losses at higher angles,
2. a rolloff in loss beginning between 10 and 15 degrees, and
3. a gradual increase in loss values with frequency.

(U) The percentage-of-data plots show that between 50 and 75 percent of the data are within ± 2 dB of the median loss curve for most angles and frequencies. It is obvious that the greatest data spread occurs at the very lowest angles.

(U) A relatively small sample set with appreciable variations rendered meaningless a similar presentation of the data from stations 1905, 1907, and 1917; those stations where a low angle increase in loss was observed.

(U) Sediment sound speed and density estimates, derived from information taken from cores throughout the region, indicate that an angle of intromission should exist in the vicinity of 10 degrees grazing. The acoustic measurement results, however, do not show conclusive evidence of intromission effects, although shot records from some stations display a phase reversal of the bottom reflected path at low angles. Reflections from the basement are present, and this energy may have masked the intromission effect.

PARKA Site

(U) The track locations and orientation of the 10 stations north of Hawaii are shown in figure 2 and described in table XXII. Data from nine sites, 2002-2010, were so nearly alike that they have been combined for presentation here. There were some unexplained anomalies in the station 2001 data, and these data have been omitted. There is some indication that the terrain along the measurement track may have been responsible for the anomalous data, but this is unproven.

(C) The ensemble average losses at four frequencies are plotted in figures 29 through 32. Superimposed on the plots are polynomial curves that NUSC, New London, had fitted to bottom loss data collected in the same region during PARKA II-A. The agreement between the two data sets is quite good, in spite of differences in measurement and processing methods, which are summarized in table XXIII. The greatest difference appears at 400 Hz, where the NUSC values are 1 to 2 dB higher than the NAVAIRDEVCEN values.

(C) Compared to the Northeast Pacific basin losses, the NAVAIRDEVCEN PARKA site losses are similar in character and somewhat on the low side.

(U) Plots showing the distribution of loss values in each of five contiguous octaves appear in figures 33 through 37. When compared to the equivalent plots for the majority of the distributed sites, figures 24 through 28, it is quite evident that the PARKA site data are much more tightly grouped, as might be expected.

Comparison to North Atlantic Losses

(U) The character and magnitude of bottom loss in the Pacific basin is very unlike data obtained previously in the North Atlantic. The data base from the Atlantic did not contain any sites over thin sediment areas at that time. Such data has since been collected and is to be reported soon.

(U) There are considerable differences between Pacific (thin sediment) and Atlantic (thick sediment) bottom losses. It has been observed that in relatively low loss regions of the Atlantic, typified by abyssal plains, the losses are only moderately frequency dependent. Losses at the lower frequencies are on the order of 0 to 2 dB at low angles, and increase to an average level of 5 dB with increasing angle from 20 to 40 degrees. Losses at higher frequencies in these same areas average 4 to 5 dB at all angles. In areas of higher loss, outside of abyssal plains (but not including regions of thin sediment), losses are much more frequency dependent below 40 to 50 degrees. Losses at low frequencies are much the same as in the low loss regions, but higher frequency losses increase to levels of 8 to 10 dB at angles as low as 10 degrees.

(U) On the whole, the Pacific basin sites may be typified as having high loss at all frequencies, at all but th low angles. In general, while there is noticeable frequency dependence in the Pacific loss characteristics, there is little grazing angle dependence above 15 degrees. Low frequency losses are typically 6 to 10 dB, and high frequency losses are more severe.

(U) The one site that is a notable exception to the bove generalizations is station 1901, the northernmost Pacific site visited. This station, unlike all the others, is outside the region of thin pelagic deposits. It is just within the boundary of a coastal region of terrigenous material, and has a loss characteristic somewhat similar to the North Atlantic data. The lack of much frequency dependence makes it appear much the same as the averaged North Atlantic low loss characteristic.

(C) TABLE I

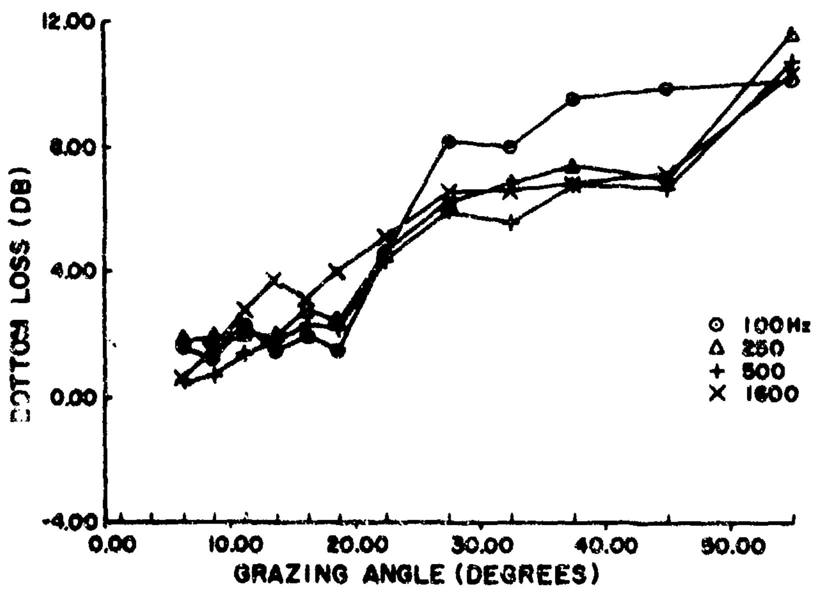
STATION 1901 (U)

(C) 1. Location: 43° 30'N, 134° 59'W; southern edge of Tufts Abyssal Plain.

(U) 2. Track: 220°

(U) 3. Sediments: 200-300 m of mud, silt and clay. Core i-190 was taken in the vicinity.

(U) 4. Remarks: Bottom loss on this station is typical of that found in abyssal plains. There is little spread among the frequencies. At high grazing angles, low frequency bottom loss may be higher than the higher frequency bottom loss. Bottom loss at angles less than 5° grazing was not obtained because strong deep ocean refracted energy contaminated the bottom reflected signals.



(U) Figure 3 - Bottom Loss, Station 1901. (U)

(C) TABLE II

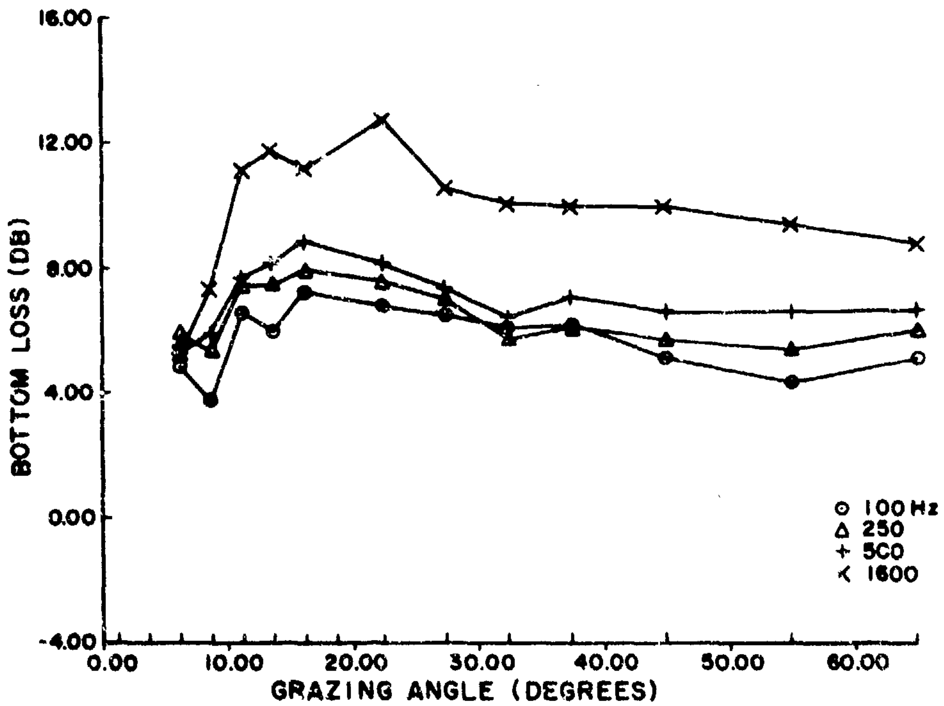
STATION 1902 (U)

(C) 1. Location: 40° 01'N, 137° 59'W; in the Pioneer Fracture Zone.

(U) 2. Track: 220°

(U) 3. Sediments: Core RC11-193 of 10 m length shows clay sediments with no reflecting layers of coarse materials. Some manganese nodules were embedded in the upper portion of the core. Sediment thickness is less than 100 m.

(U) 4. Remarks: The sound velocity profile for this station showed considerable depth excess, 2250 m in a 4850 m ocean. Bottom reflected signals arriving at the receiver with bottom grazing angles of less than 4.5° were unreliable because of the presence of strong ocean refracted signals.



(U) Figure 4 - Bottom Loss, Station 1902. (U)

(C) TABLE III

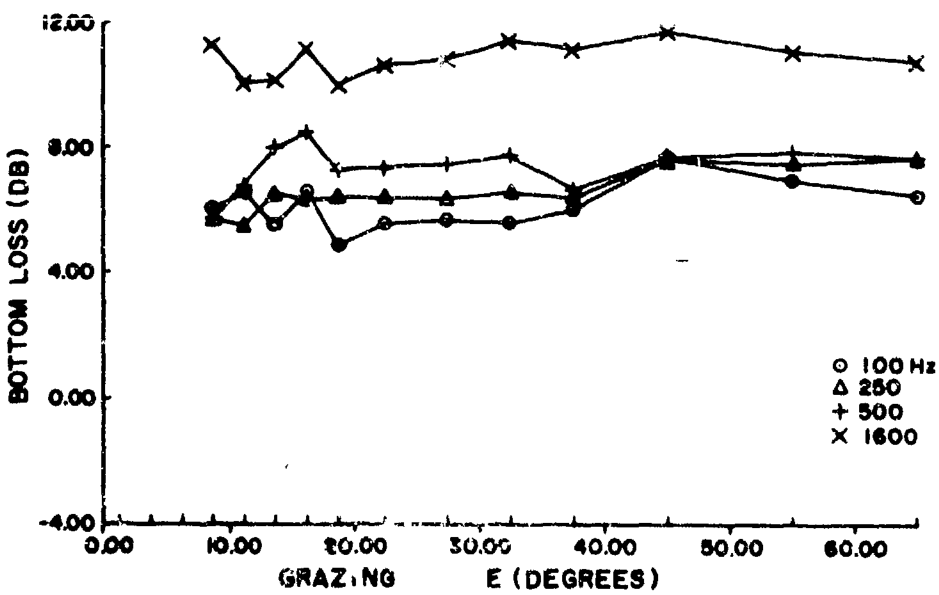
STATION 1903 (U)

(C) 1. Location: 37° 59'N, 141° 00'W; Mendocino Fracture Zone.

(U) 2. Track: 120°

(U) 3. Sediments: Pelagic clay sediments of less than 100 m thickness.

(U) 4. Remarks: To a 300 ft receiver, the depth excess is 54 percent of the ocean depth - 2960 m in a 5460 m ocean depth. Signals from bottom reflected signals below about 5° are unuseable because of the presence of strong ocean refracted arrivals.



(U) Figure 5 - Bottom Loss, Station 1903. (U)

(C) TABLE IV

STATION 1904 (U)

(C) 1. Location: 47° 40'N, 139° 59'W; between the Murray and Pioneer Fracture Zones. Bathymetric charts show the area to be featureless.

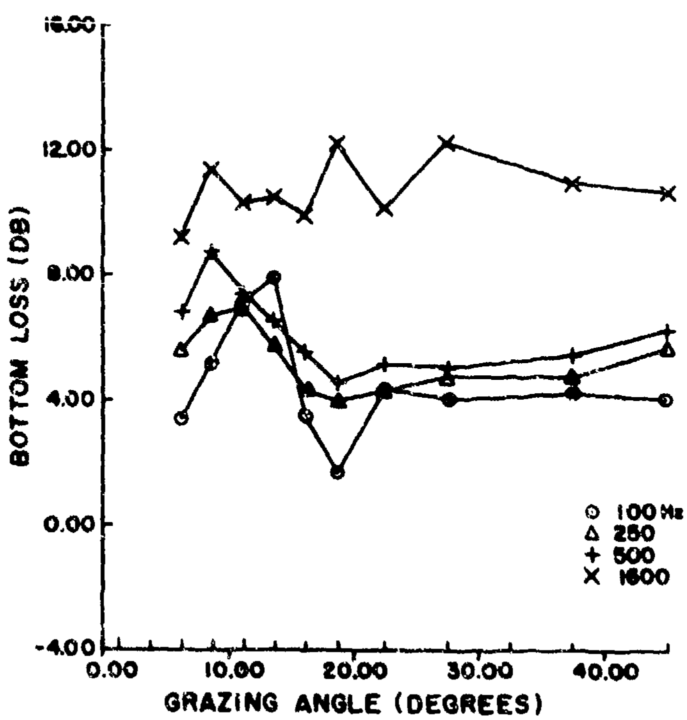
(U) 2. Track: 178°

(U) 3. Sediments: Pelagic clay sediments of less than 100 m thickness.

(U) 4. Remarks: No bottom loss data is available for grazing angles less than 5° because of the presence of deep ocean refracted energy.

(U) Bottom loss for frequencies of 500 Hz and lower is about 6 dB less than that for 1600 Hz.

(U) Shot records show many returns, too numerous to be accounted for by the four bottom reflected paths.



(U) Figure 6 - Bottom Loss, Station 1904. (U)

(C) TABLE V

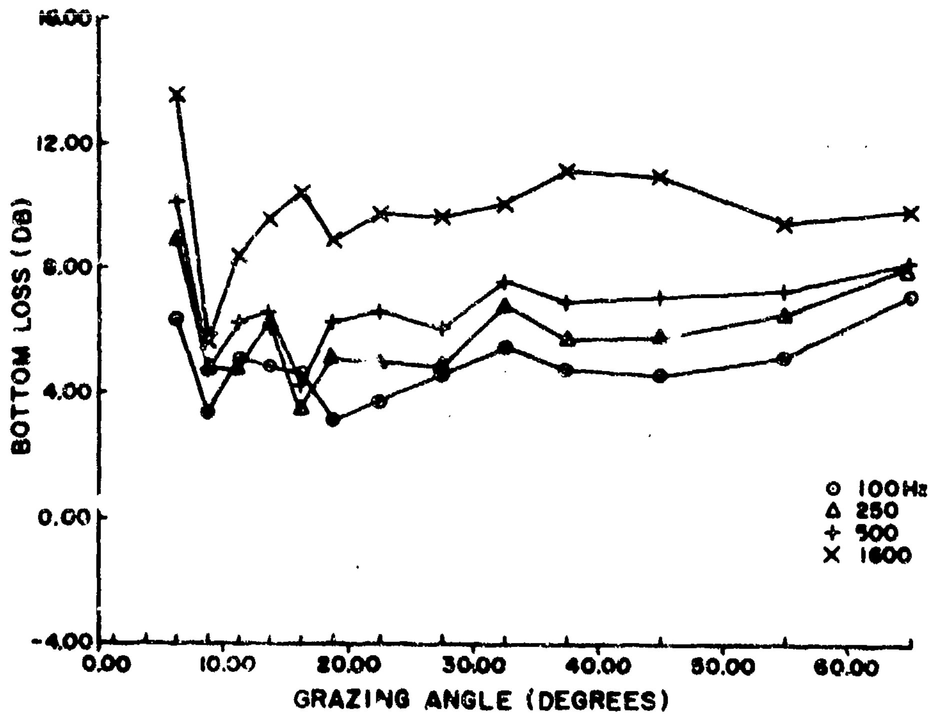
STATION 1905 (U)

(C) 1. Location: 36° 24'N, 138° 58'W; between the Pioneer and Murray Fracture Zones.

(U) 2. Track: 135°

(U) 3. Sediments: Core VC20-71, taken in this area, is composed of pelagic clays. The sound velocity in the sediment was found to be 1492 m/sec. The velocity of the water at the bottom sediment interface is about 1549 m/sec. Sediment thickness is less than 100 m.

(U) 4. Remarks: Data is lacking below 5° grazing for reasons mentioned in the preceding station descriptions. Bottom loss below 10° grazing increases sharply. Depth excess is about 1400 m.



(U) Figure 7 - Bottom Loss, Station 1905. (U)

(C) TABLE VI

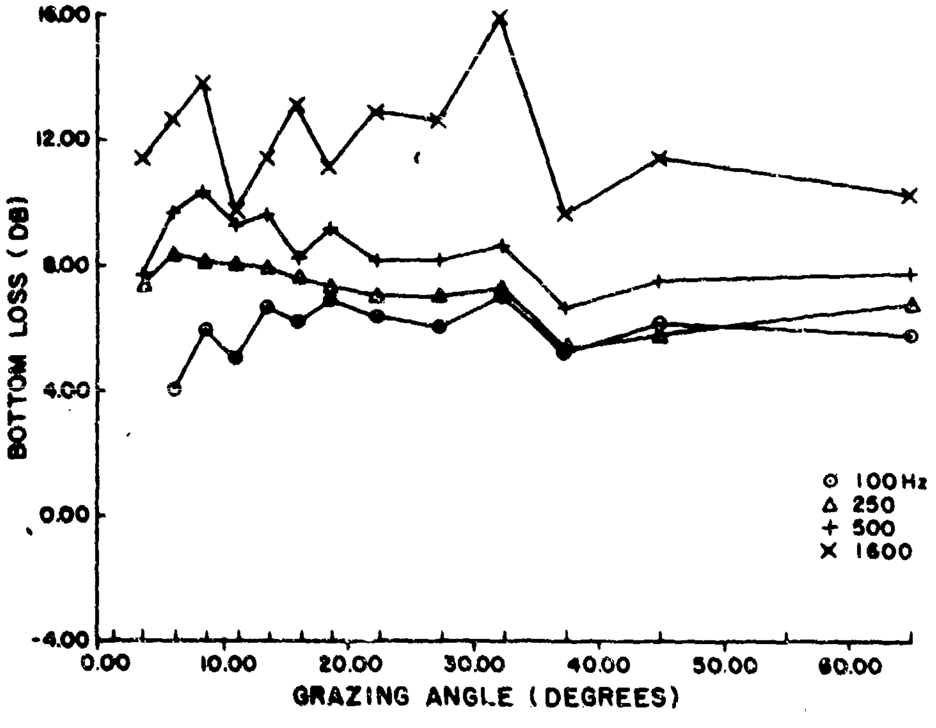
STATION 1906 (U)

(C) 1. Location: 35° 50'N, 137° 27'W; between the Pioneer and Murray Fracture Zones.

(U) 2. Track: 90°

(U) 3. Sediments: The core information listed for station 1905 applies to this station also. Sediments are less than 100 m thick.

(U) 4. Remarks: No data available below grazing angles of 4° because of the presence of deep-ocean refracted energy.



(U) Figure 8 - Bottom Loss, Station 1906. (U)

(C) TABLE VII

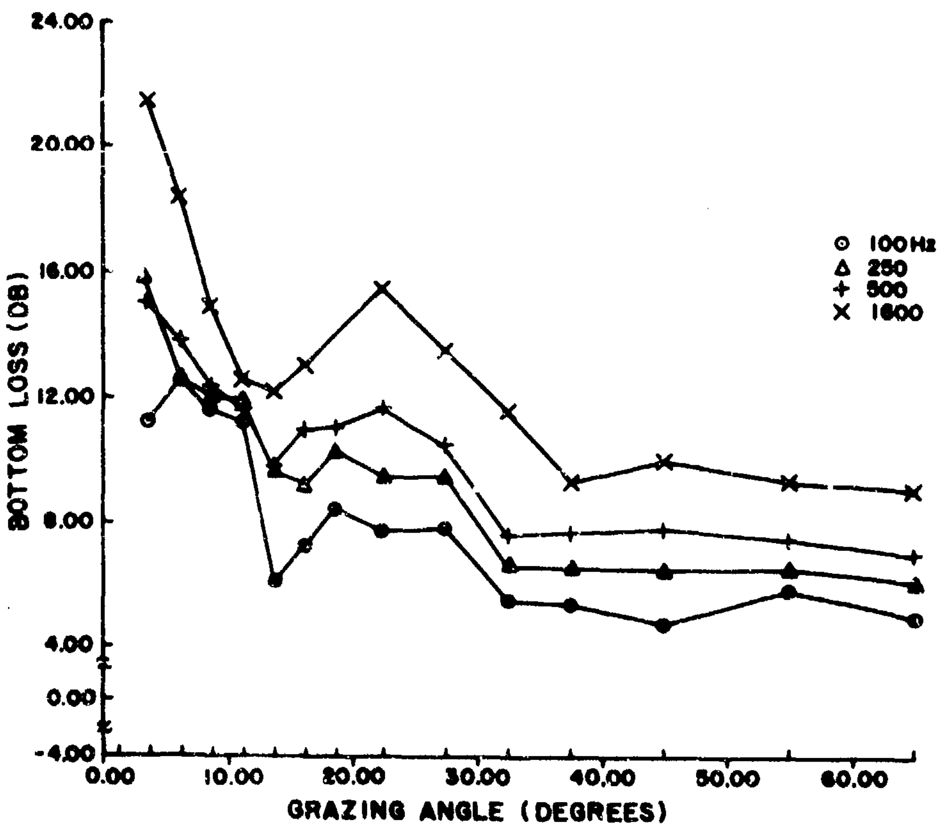
STATION 1907 (U)

(C) 1. Location: 27° 58'N, 133° 59'W; Baja California Seamount Province. Topography is rugged regionally and locally.

(U) 2. Track: 220°

(U) 3. Sediments: Pelagic clay with thickness no greater than 100 m.

(U) 4. Remarks: Bottom loss data extends to 2.5° grazing. There is a sharp increase in bottom loss i the 10°-0° grazing range. Depth excess on this station is about 1000 m.



(U) Figure 9 - Bottom Loss, Station 1907. (U)

(C) TABLE VIII

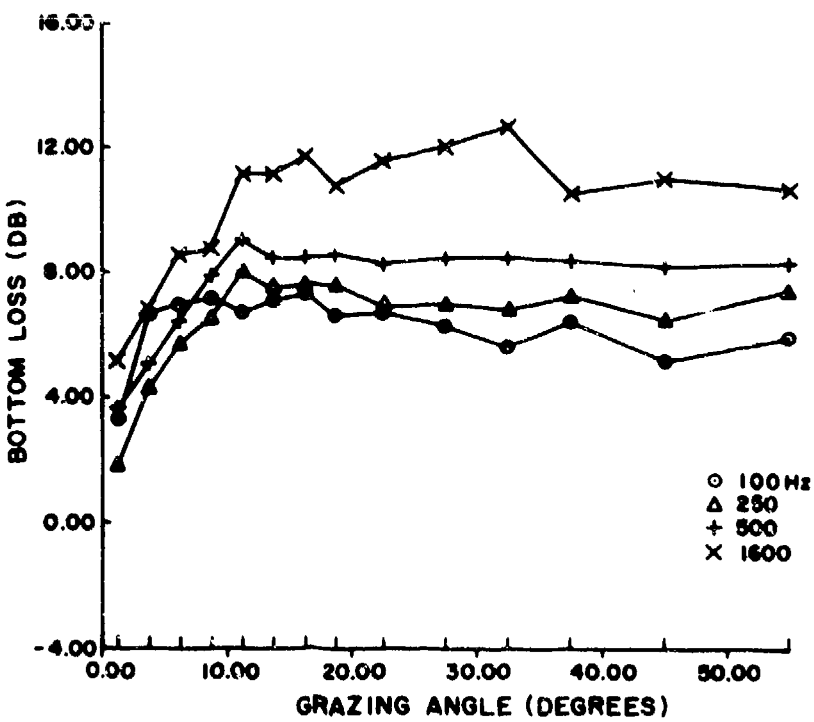
STATION 1908 (U)

(C) 1. Location: 25° 59'N, 135° 20'W; Baja California Seamount Province and adjacent to the Molokai Fracture Zone. Topography is relatively smooth along the track of measurements.

(U) 2. Track: 130°

(U) 3. Sediments: Pelagic clay of less than 100 m thickness.

(U) 4. Remarks: Depth excess at this station is 900 m in water 4900 m deep. The grazing angle at which bottom reflected signals are contaminated by deep ocean refracted signals is less than 1°. The range of bottom loss measurements for this station extend from 55° to 1° grazing angles. This station provides a good example of one of the predominant types of loss behavior found in this series of tests.



(U) Figure 10 - Bottom Loss, Station 1908. (U)

(C) TABLE IX

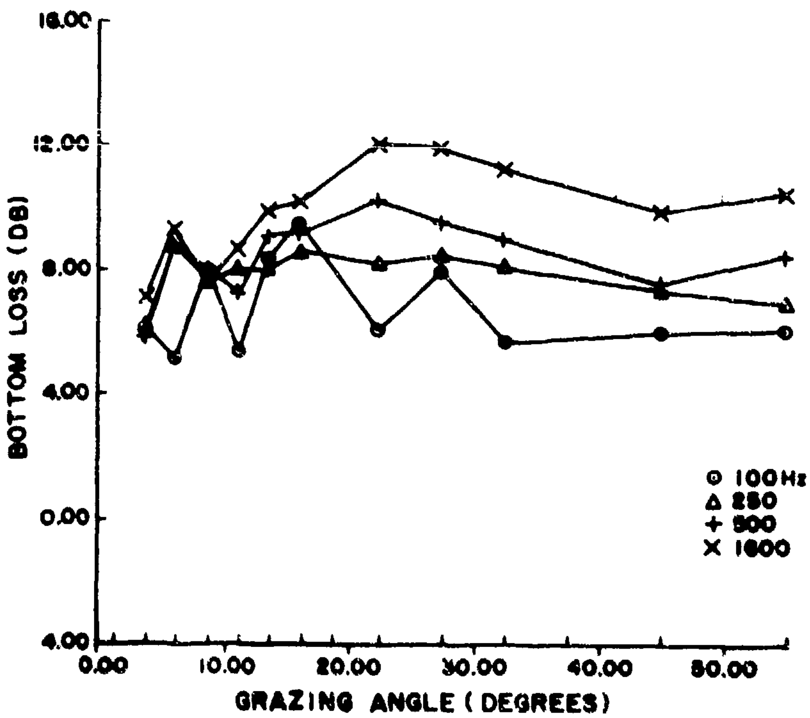
STATION 1909 (U)

(C) 1. Location: 29° 18'N, 135° 15'W; Baja California Seamount Province. Topography is rough.

(U) 2. Track: 039°

(U) 3. Sediments: Sediments are predominately pelagic clay of less than 100 m thickness. In a seamount province, sediment thickness is likely to be more erratic than uniform.

(U) 4. Remarks: No bottom loss data available below 2° grazing angle.



(U) Figure 11 - Bottom Loss, Station 1909. (U)

(C) TABLE X

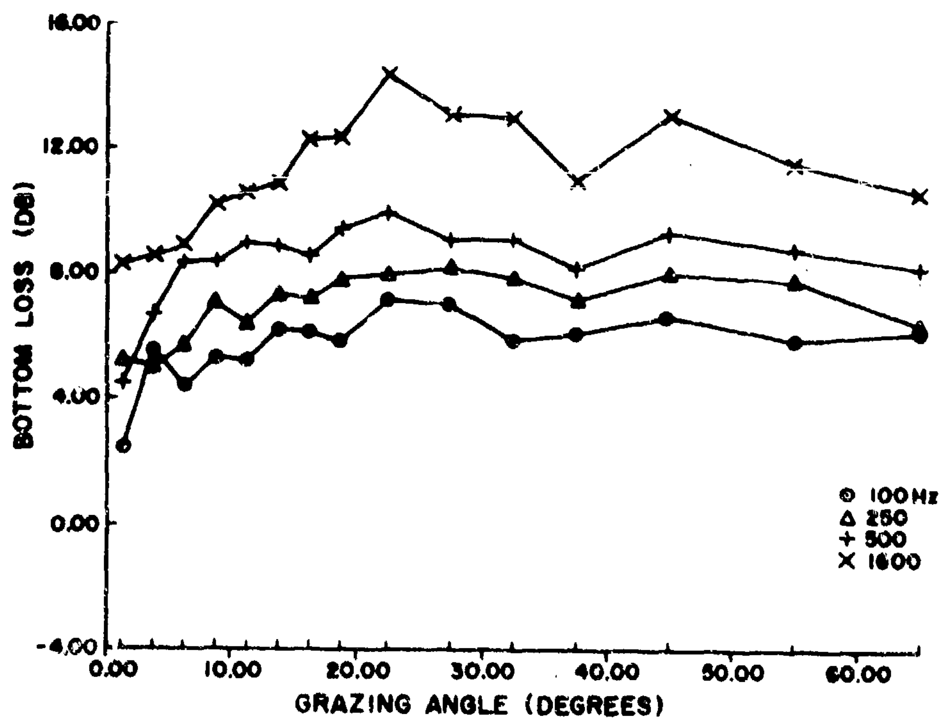
STATION 1910 (U)

(C) 1. Location: 24° 30'N, 132° 55'W; Molokai Fracture Zone.

(U) 2. Track: 090°

(U) 3. Sediments: Pelagic clay, less than 100 m thick.

(U) 4. Remarks: Bottom loss data available for grazing angles of 1° to 65°. Bottom loss at this station falls into a group typified by station 1908.



(U) Figure 12 - Bottom Loss, Station 1910. (U)

(C) TABLE XI

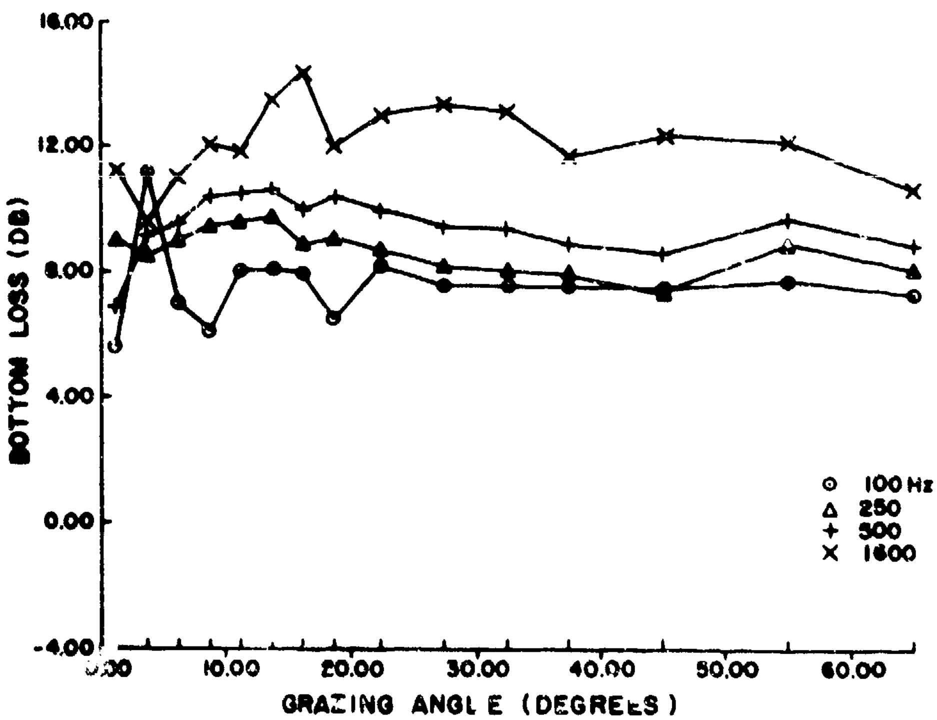
STATION 1911 (U)

(C) 1. Location: 25° 03'N, 131° 27'W; Molokai Fracture Zone. Topography along the track is relatively smooth.

(U) 2. Track: 044°

(U) 3. Sediments: Pelagic clay, less than 100 m thick.

(U) 4. Remarks: Bottom loss information available for 1° grazing angle to 65°. At 3.75° grazing angle there is an apparent anomaly in the 100 Hz curve. Otherwise, station 1911 groups with stations 1908 and 1910.



(U) Figure 13 - Bottom Loss, Station 1911. (U)

(C) TABLE XII

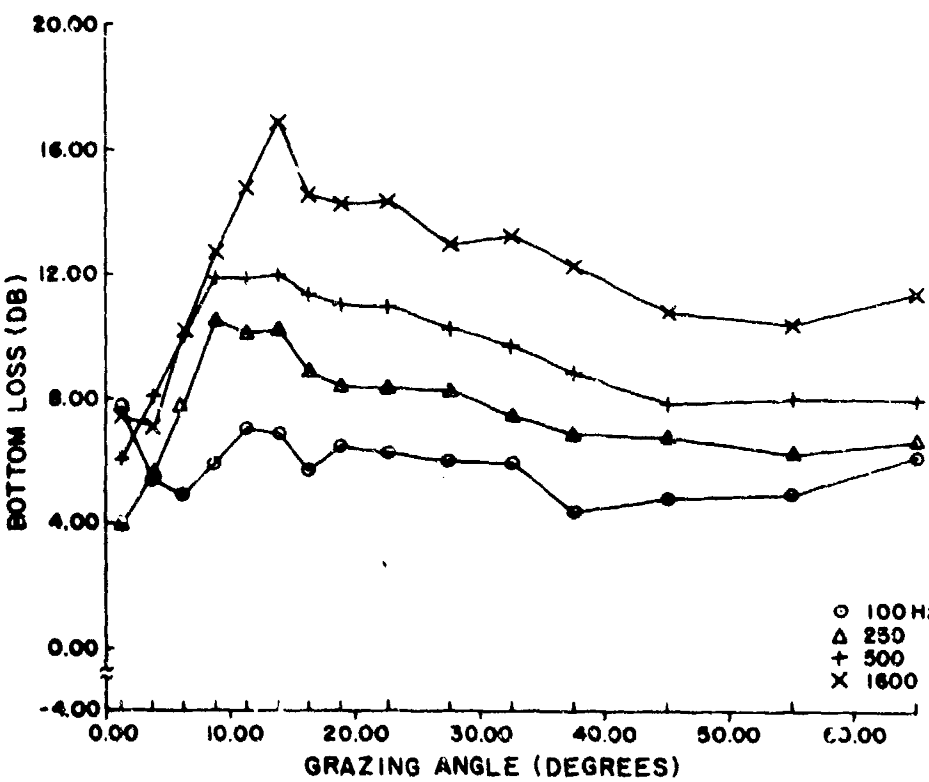
STATION 1912 (U)

(C) 1. Location: 26° 32'N, 129° 58'W; Baja California Seamount Province.

(U) 2. Track: 043°

(U) 3. Sediments: Core RC10-234 was taken close to this station. In the 4.5 m length of core, mud and clay predominate. Sound speed in the sediment was about 50 m/sec less than that of the water at the bottom. Sediment thickness is less than 100 m.

(U) 4. Remarks: A characteristic of bottom loss at this station is the spread of bottom loss among the four frequencies shown - about 3 dB. There is a maximum loss for all frequencies at 10° - and a sharp decrease as grazing angle decreases below this angle. Compare these results to those of 1913-1916.



(U) Figure 14 - Bottom Loss, Station 12. (U)

(C) TABLE XIII

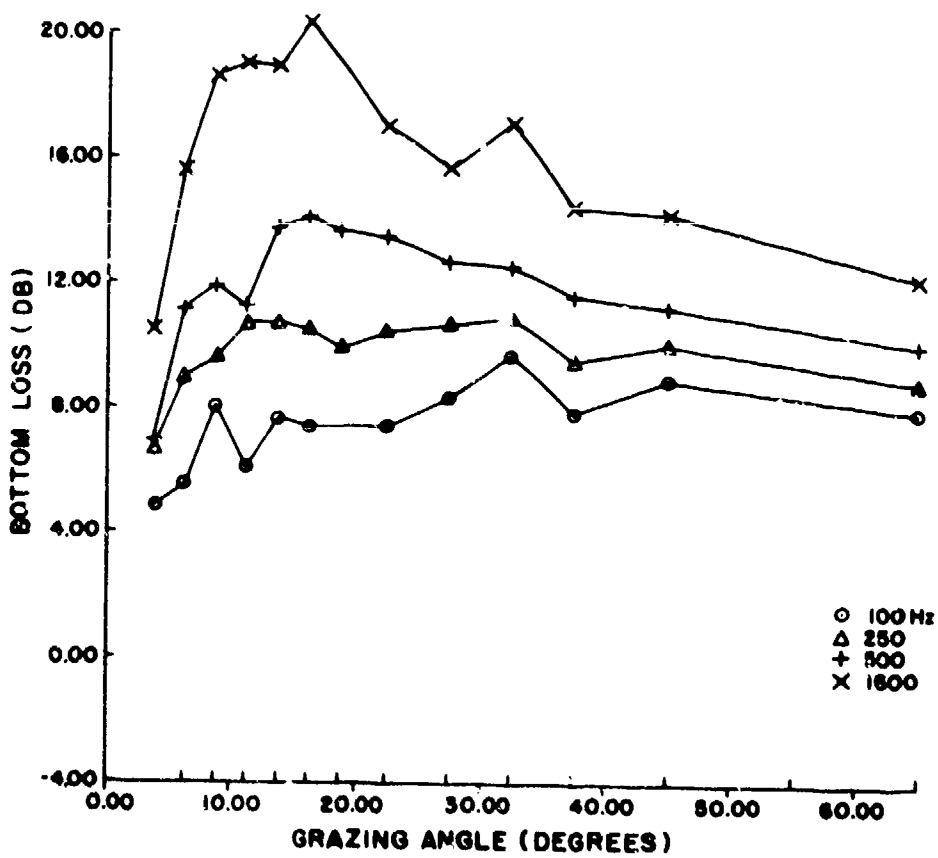
STATION 1913 (U)

(C) 1. Location: 18° 58'N, 128° 02'W; Clarion Fracture Zone.

(U) 2. Track: 119°

(U) 3. Sediments: Pelagic clay with some rock and gravel. Thickness is less than 100 m.

(U) 4. Remarks: Station 1913 is the highest loss station found in this series of measurements. Other stations with bottom loss having the same behavior are 1912, and 1914-1916.



(U) Figure 15 - Bottom Loss, Station 1913. (U)

(C) TABLE XIV

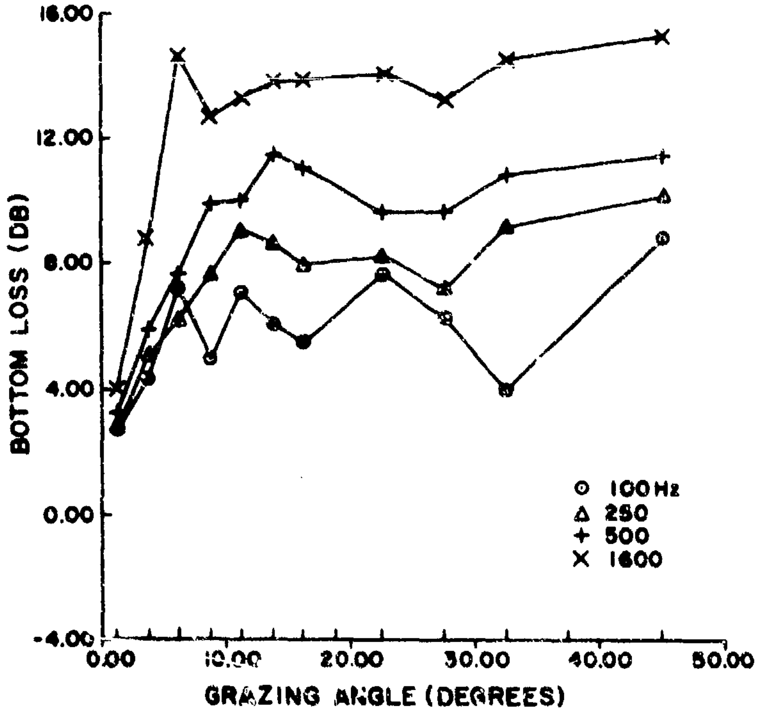
STATION 1914 (U)

(C) 1. Location: 20° 27'N, 128° 00'W; in the northern edge of the Clarion Fracture Zone.

(U) 2. Track: 178°

(U) 3. Sediments: Less than 100 m thick, consisting of pelagic clay with some rock and gravel. Cores RC10-236 and RC10-237, both less than 10 m long, are composed of mud and clay. Sound speed in the sediments was about 50 m/sec less than that of the water at the bottom.

(U) 4. Remarks: No data available above 45° grazing.



(U) Figure 16 - Bottom Loss, Station 1914. (U)

(C) TABLE XV

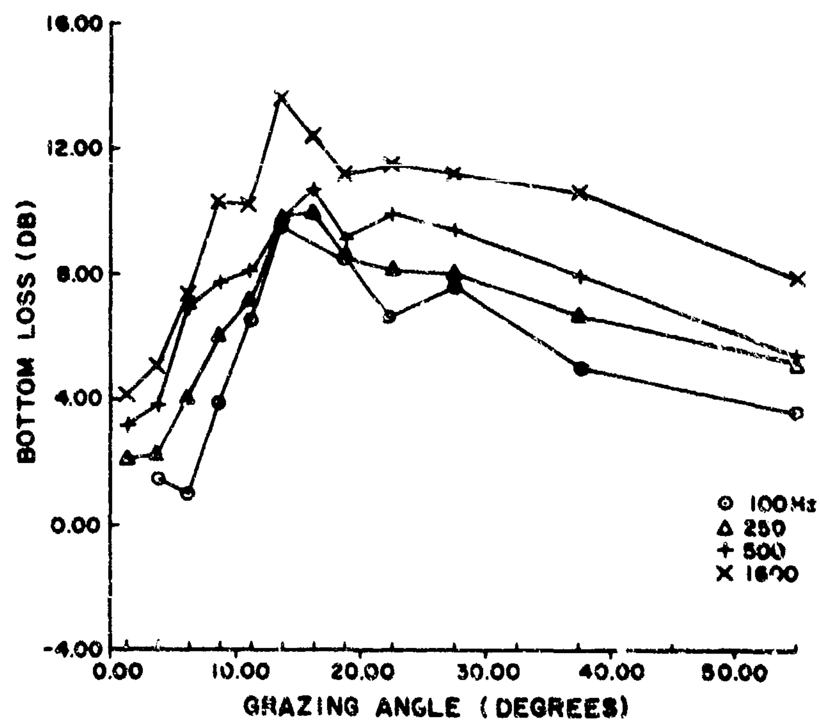
STATION 1915 (U)

(C) 1. Location: 18° 01'N, 122° 31'W; Clarion Fracture Zone.

(U) 2. Track: 000°

(U) 3. Sediments: Pelagic clay with thickness less than 100 m.

(U) 4. Remarks: Shot records show good reflection from layers or from the basement rock. Character of bottom loss resembles preceding stations but of lower magnitude.



(U) Figure 17 - Bottom Loss, Station 1915. (U)

(C) TABLE XVI

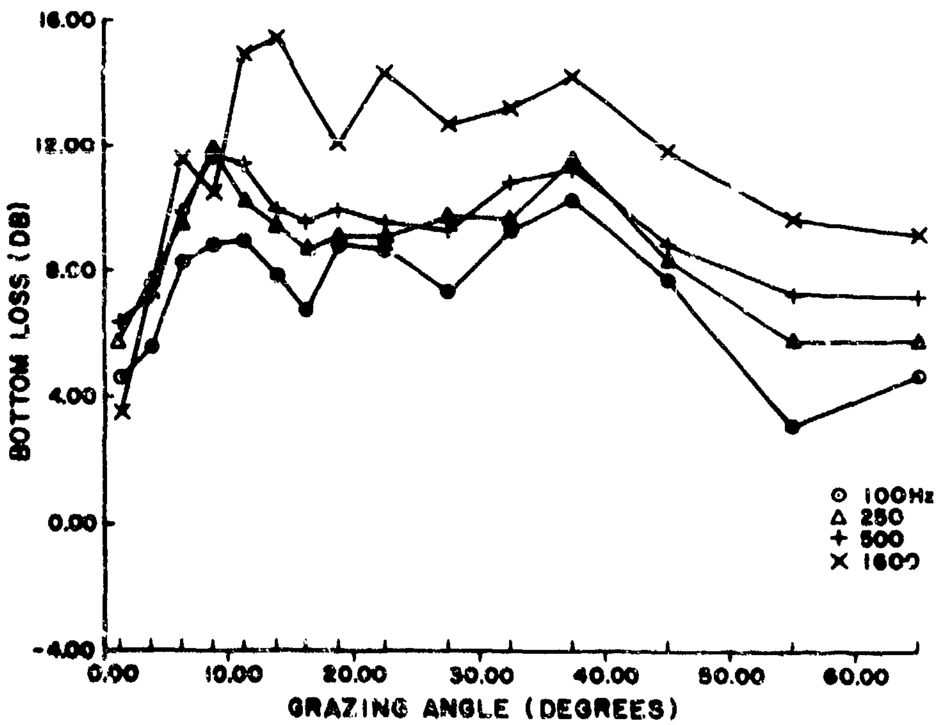
STATION 1916 (U)

(C) 1. Location: 19° 40'N, 117° 00'W; Clarion Fracture Zone. Alphecca Seamount (155 m) is near end of track.

(U) 2. Track: 180°

(U) 3. Sediments: Pelagic clay, less than 100 m thick.

(U) 4. Remarks: Energy returned from seamount did not affect bottom loss calculations.



(U) Figure 18 - Bottom Loss, Station 1916. (U)

(C) TABLE XVII

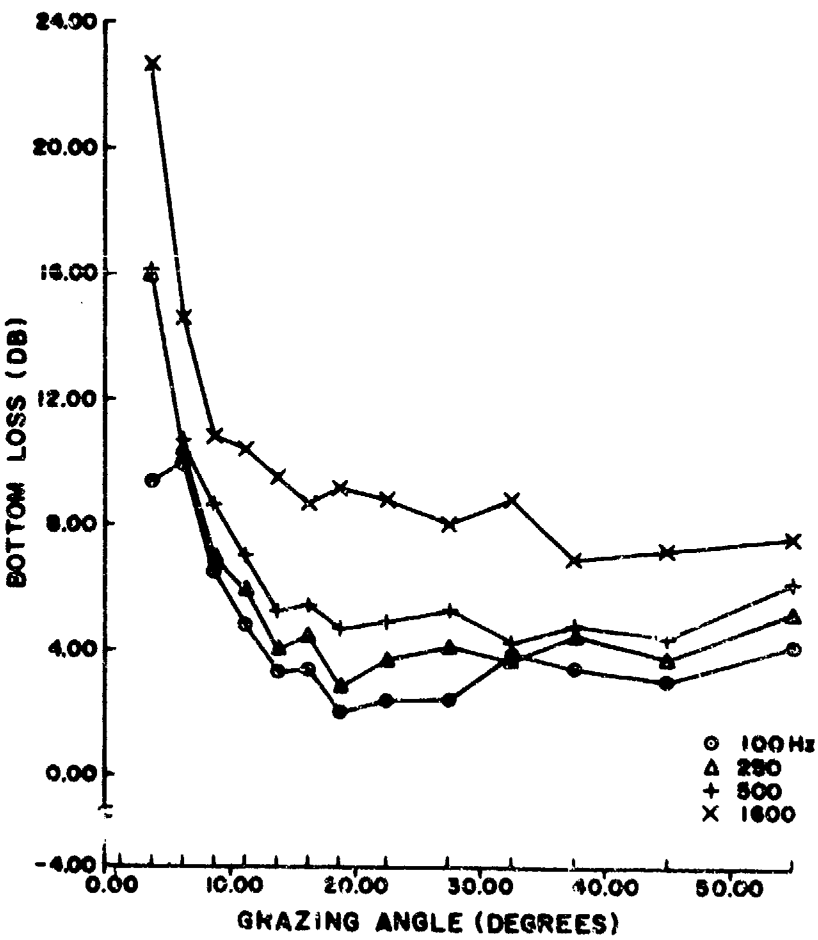
STATION 1917 (U)

(C) 1. Location: 17° 25'N, 116° 33'W; Clarion Fracture Zone. Measurement track passes within 16 km of Shimada Seamount (20 m).

(U) 2. Track: 225°

(U) 3. Sediments: Sediments on this station are typical of the entire Central Pacafic basin, pelagic clay not exceeding 100 m thickness.

(U) 4. Remarks: The sound speed profile for this station shows bottom



(U) Figur 19 - Bottom Loss, Station 1917. (U)

(C) TABLE XVII (Cont)

limiting - below 3^{o} grazing no bottom reflected signal paths strike the hydrophone. This station falls into the same group of bottom loss behavior as stations 1905 and 1907, which are not bottom limited.

(U) Most of the stations in this test have similar sediments and thickness of sediments. Only stations 1905, 1907, and 1917 show a sharp increase in bottom loss for the 10^{o} -0^{o} angles.

(C) TABLE XVIII

STATION 1918 (U)

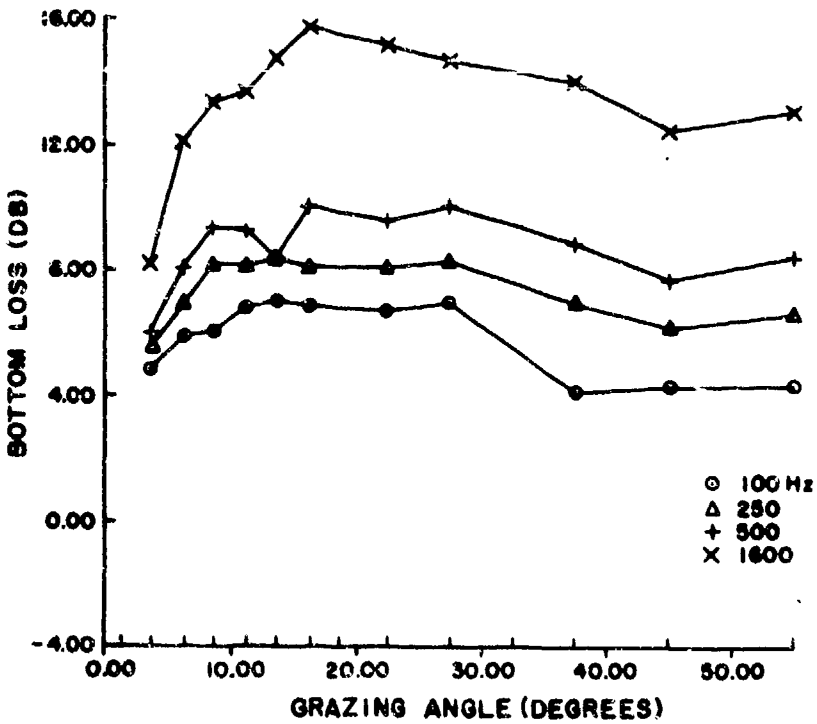
(C) 1. Location: 16° 00'N, 118° 59'W; south of the Clarion Fracture Zone.

(U) 2. Track: 270°

(U) 3. Sediments: Pelagic clay of less than 100 m thickness.

(U) 4. Remarks: No data available below 2.5° grazing angle. There is about 5-6 dB spread between loss at 1600 Hz and the loss at the lower frequencies. With station 1912, station 1918 exhibits the highest bottom loss in this series of tests.

(U) Shot returns are characterized by many short duration spikes.



(U) Figure 20 - Bottom Loss, Station 1918. (U)

(C) TABLE XIX

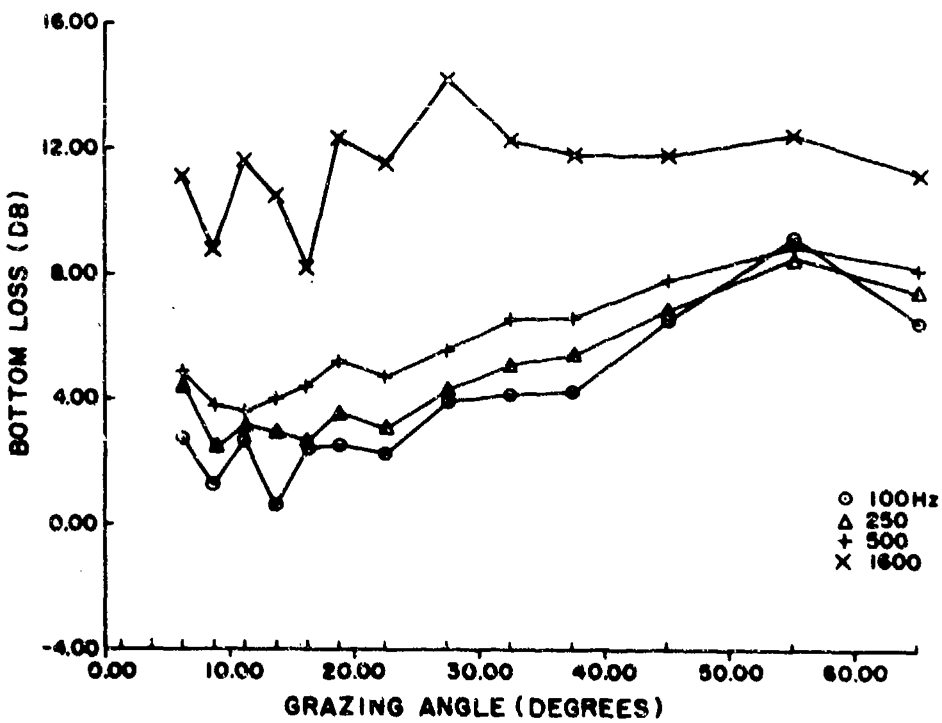
STATION 2011 (U)

(C) 1. Location: 32° 03'N, 146° 29'W; north of the Murray Fracture Zone. Terrain is relatively smooth over the measurement track.

(U) 2. Track: 000°

(U) 3. Sediments: Less than 100 m of pelagic clay sediments. Core V20-68, 5 m long, shows clay sediment and a sound speed of 1500 m/sec.

(U) 4. Remarks: Except for a few irregularities at 1600 Hz, bottom loss character is very similar to that found at station 1918.



(U) Figure 21 - Bottom Loss, Station 2011. (U)

(C) TABLE XX

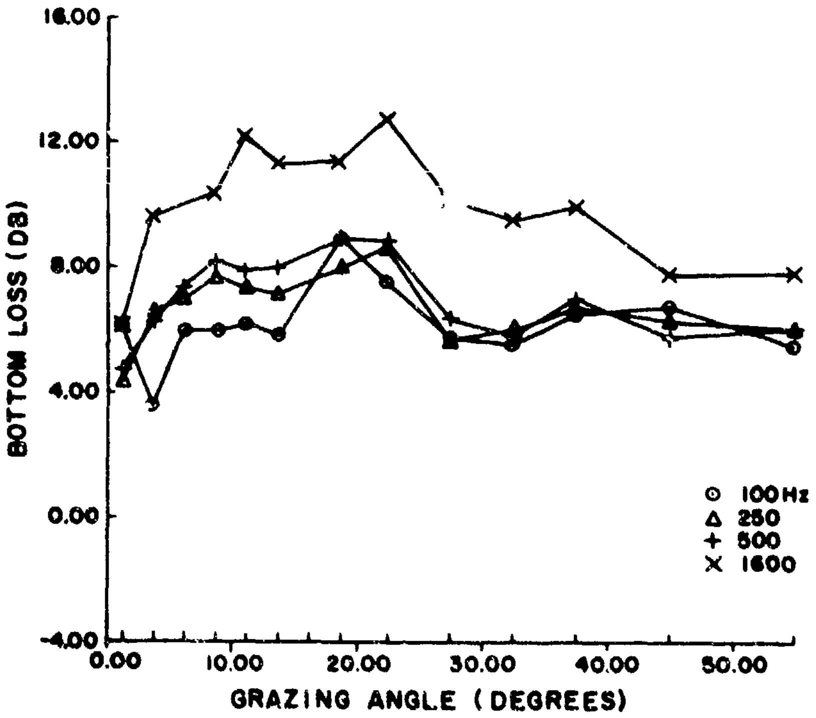
STATION 2012 (U)

(C) 1. Location: 22° 37'N, 147° 19'W; the station track crosses one of the deep troughs running through the Molokai Fracture Zone.

(U) 2. Track: 000°

(U) 3. Sediments: Less than 100 m of pelagic clay sediments.

(U) 4. Remarks: Bottom loss at 1600 Hz is about 3 dB higher than the other three frequencies shown - and which are tightly grouped.



(U) Figure 22 - Bottom Loss, Station 2012. (U)

(C) TABLE XXI

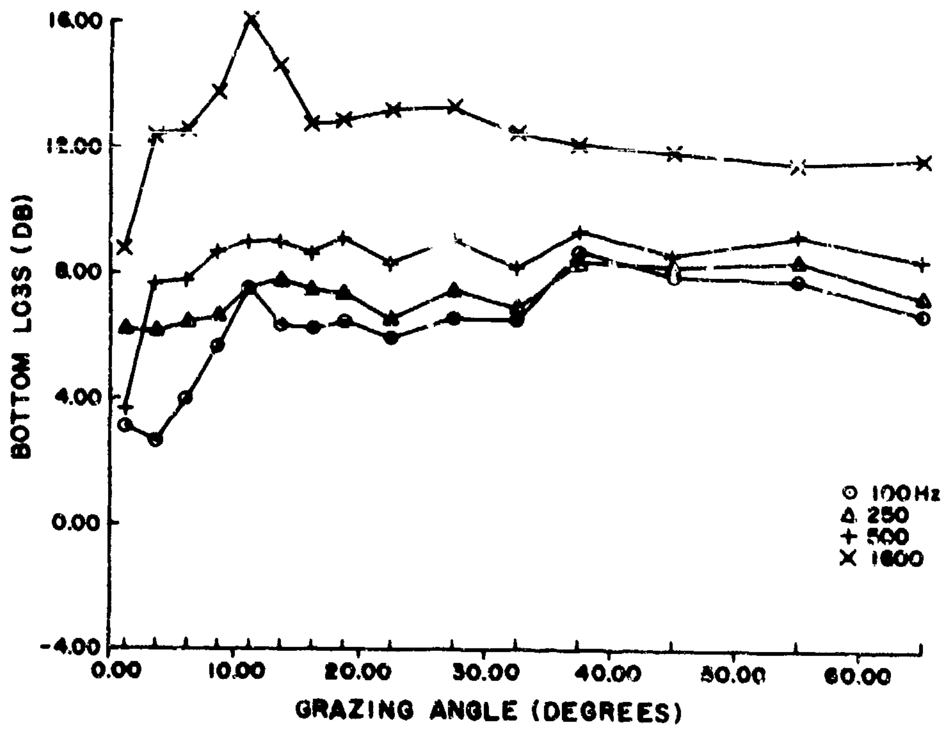
STATION 2013 (U)

(C) 1. Location: 26° 27'N, 146° 56'W; in a seamount-studded area between Molokai and Murray Fracture Zones. Track runs close to a seamount rising 1000 m above the surrounding sea floor.

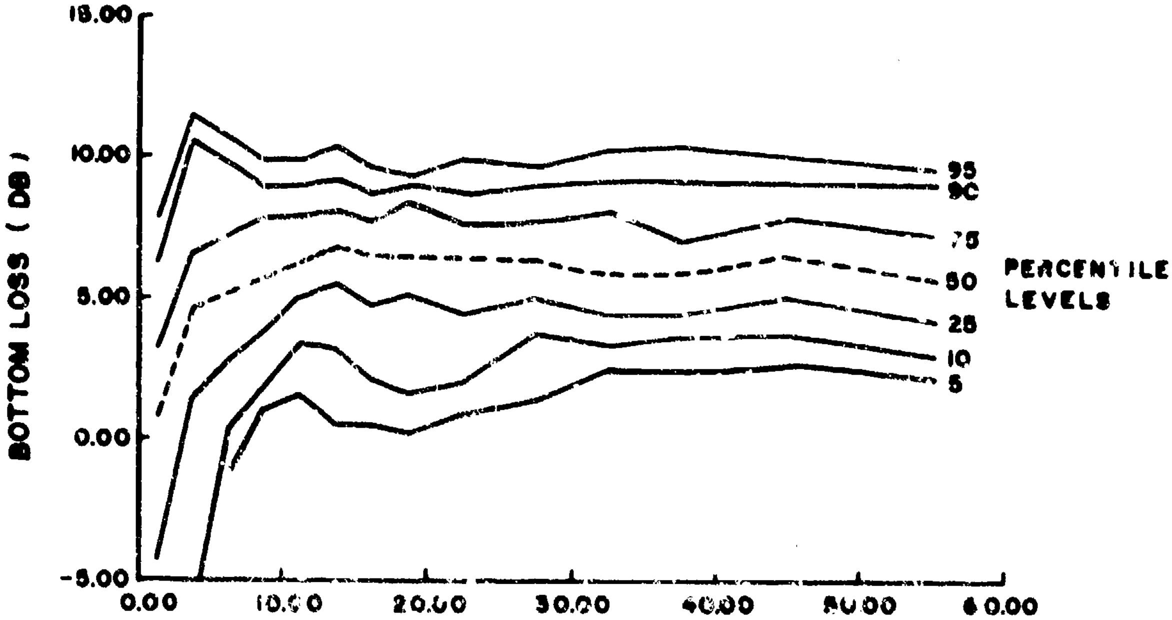
(U) 2. Track: 289°

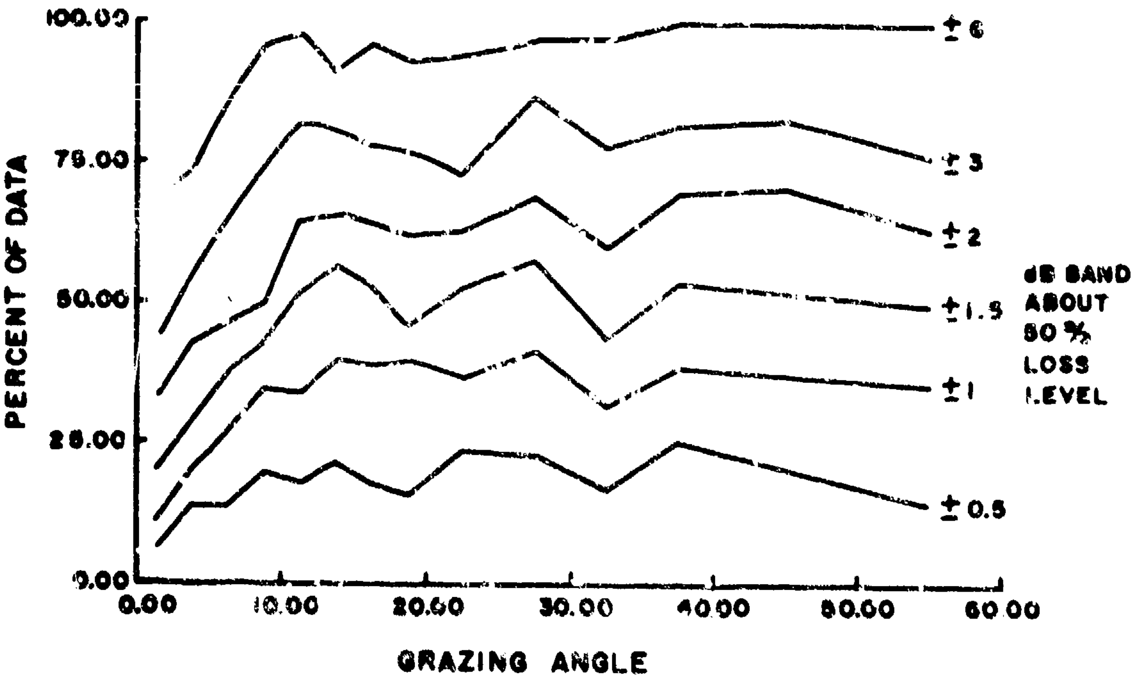
(U) 3. Sediments: Pelagic clay of less than 100 m thickness.

(U) 4. Remarks: Bottom loss curves have 5-6 dB spread between 1600 Hz and the lower frequencies, which are quite similar in loss magnitude.

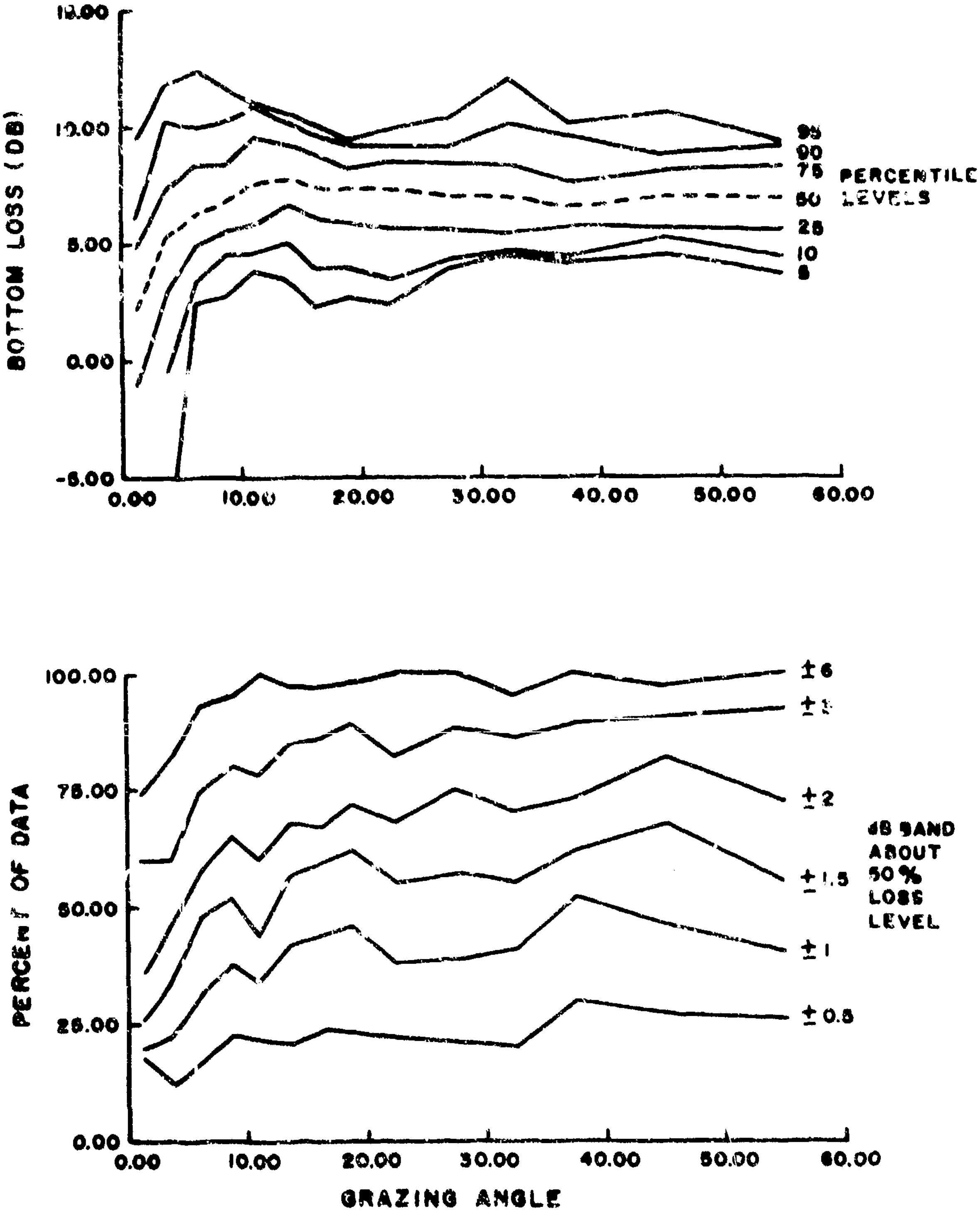


(U) Figure 23 - Bottom Loss, Station 2013. (U)

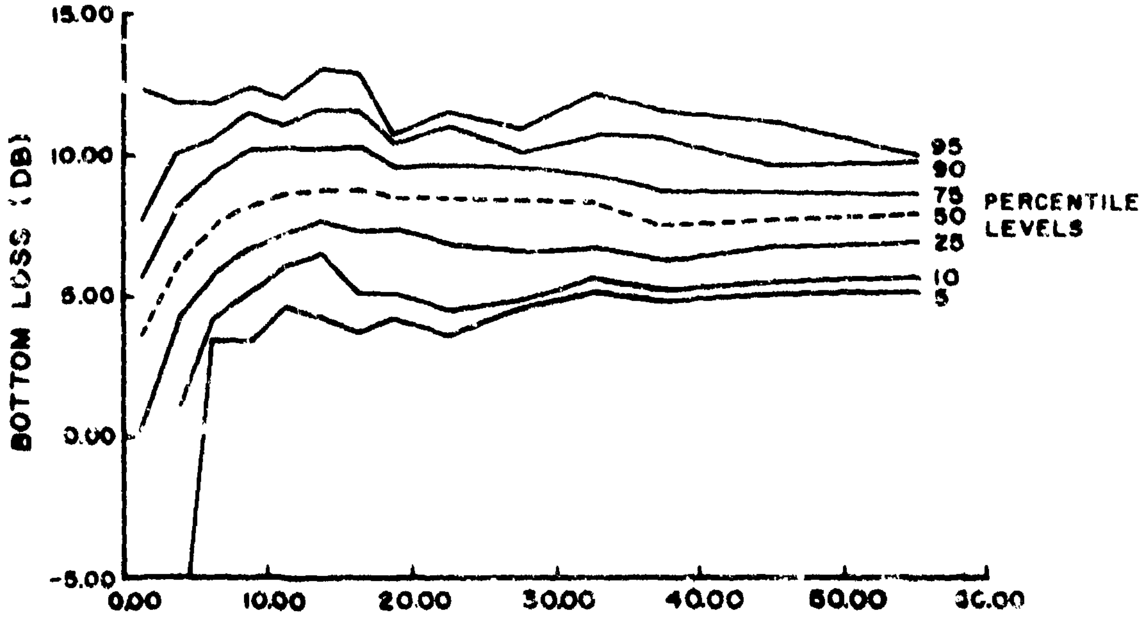


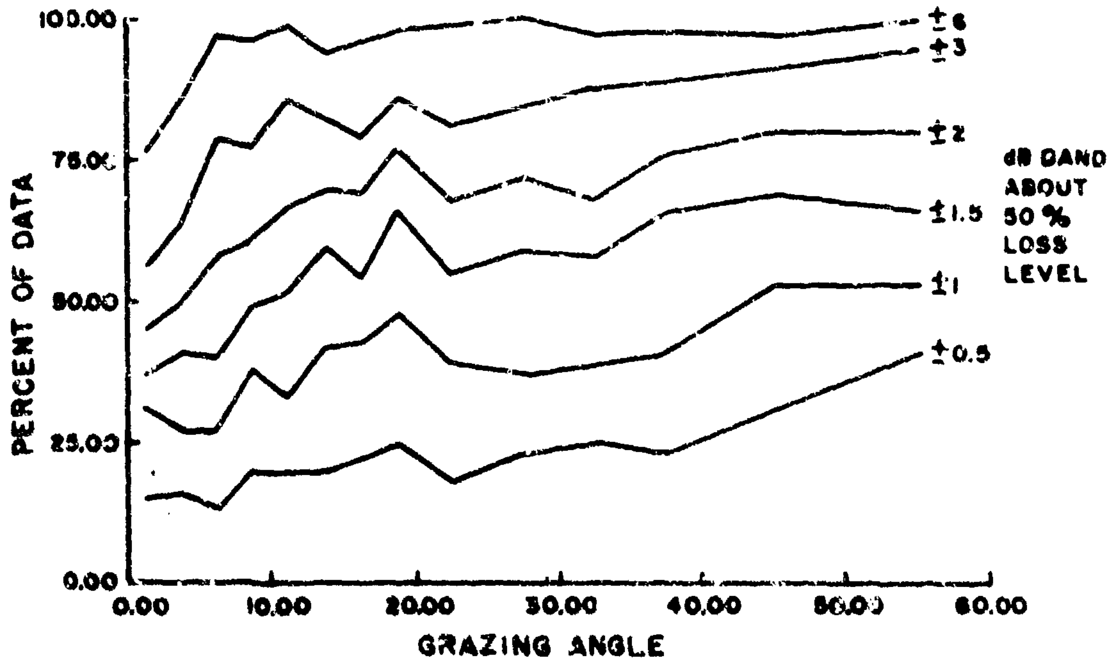


(U) Figure 24 - Pacific Basin Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angles: 100 Hz octave. (U)

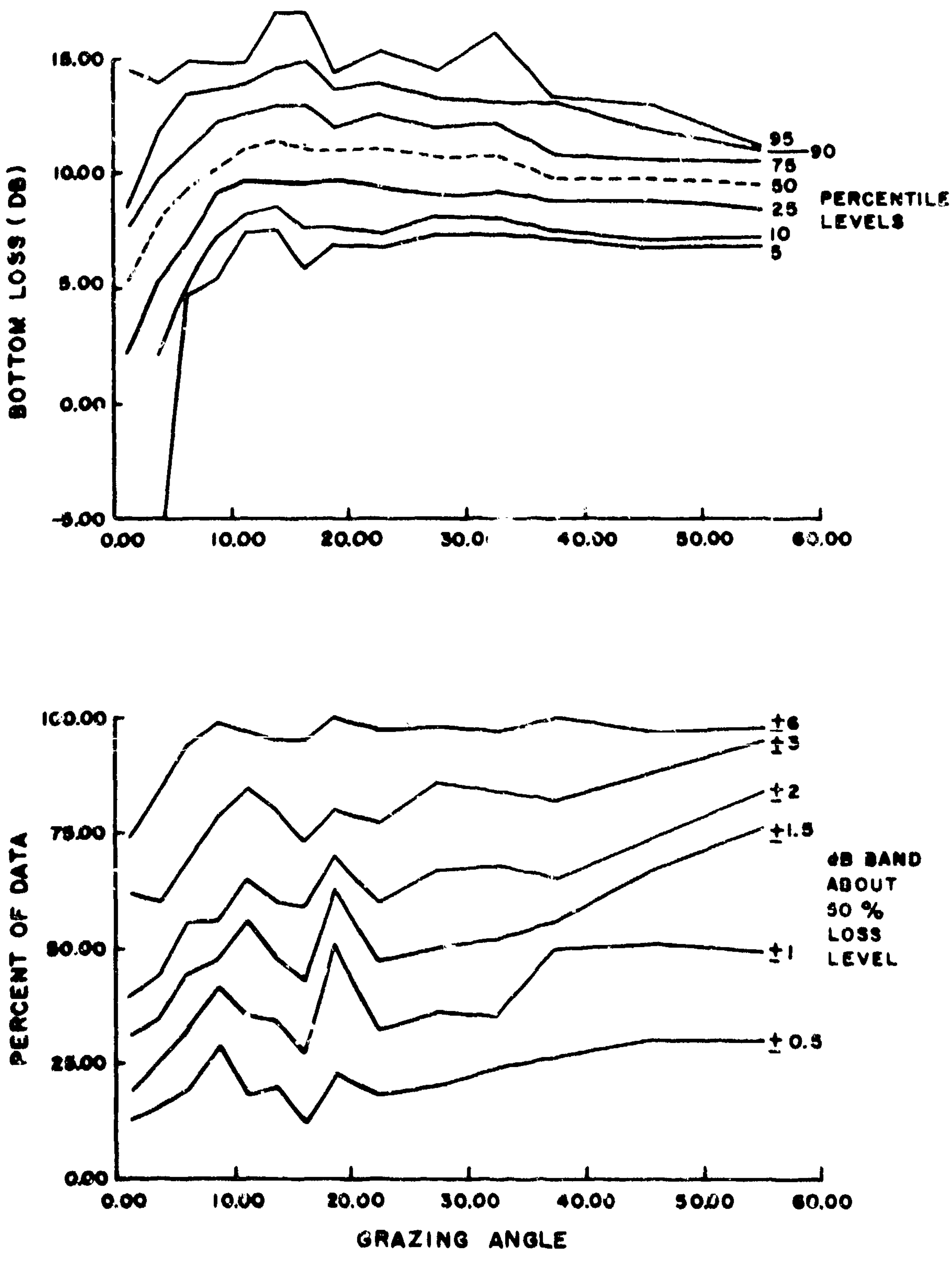


(U) Figure 25 - Pacific Basin Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 200 Hz octave. (U)

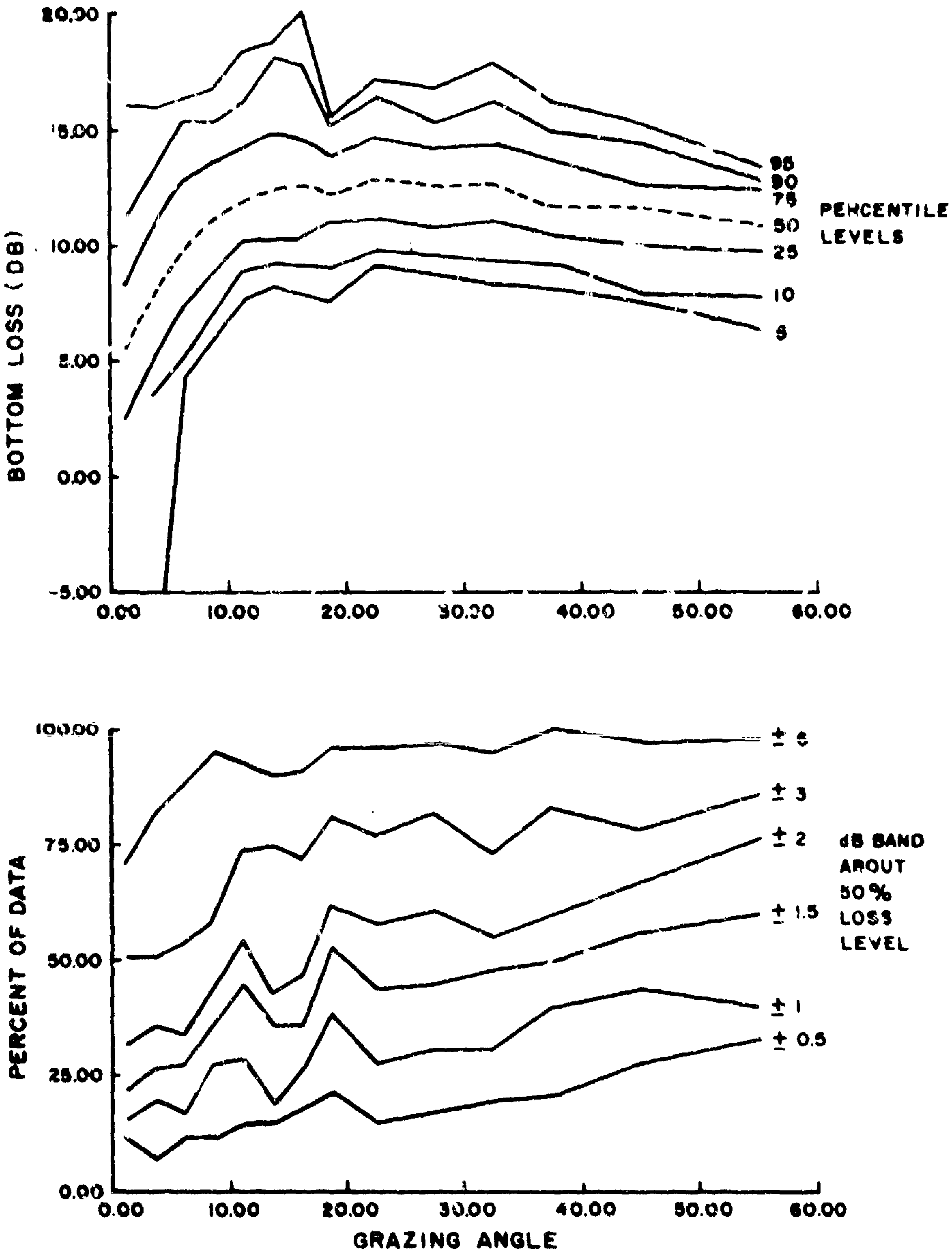




(U) Figure 26 - Pacific Basin Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 400 Hz octave. (U)



(U) Figure 2. - Pacific Basin Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 800 Hz octave.



(U) Figure 28 - Pacific Basin Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 1600 Hz octave. (U)

(C) TABLE XXII

PARKA STATIONS (U)

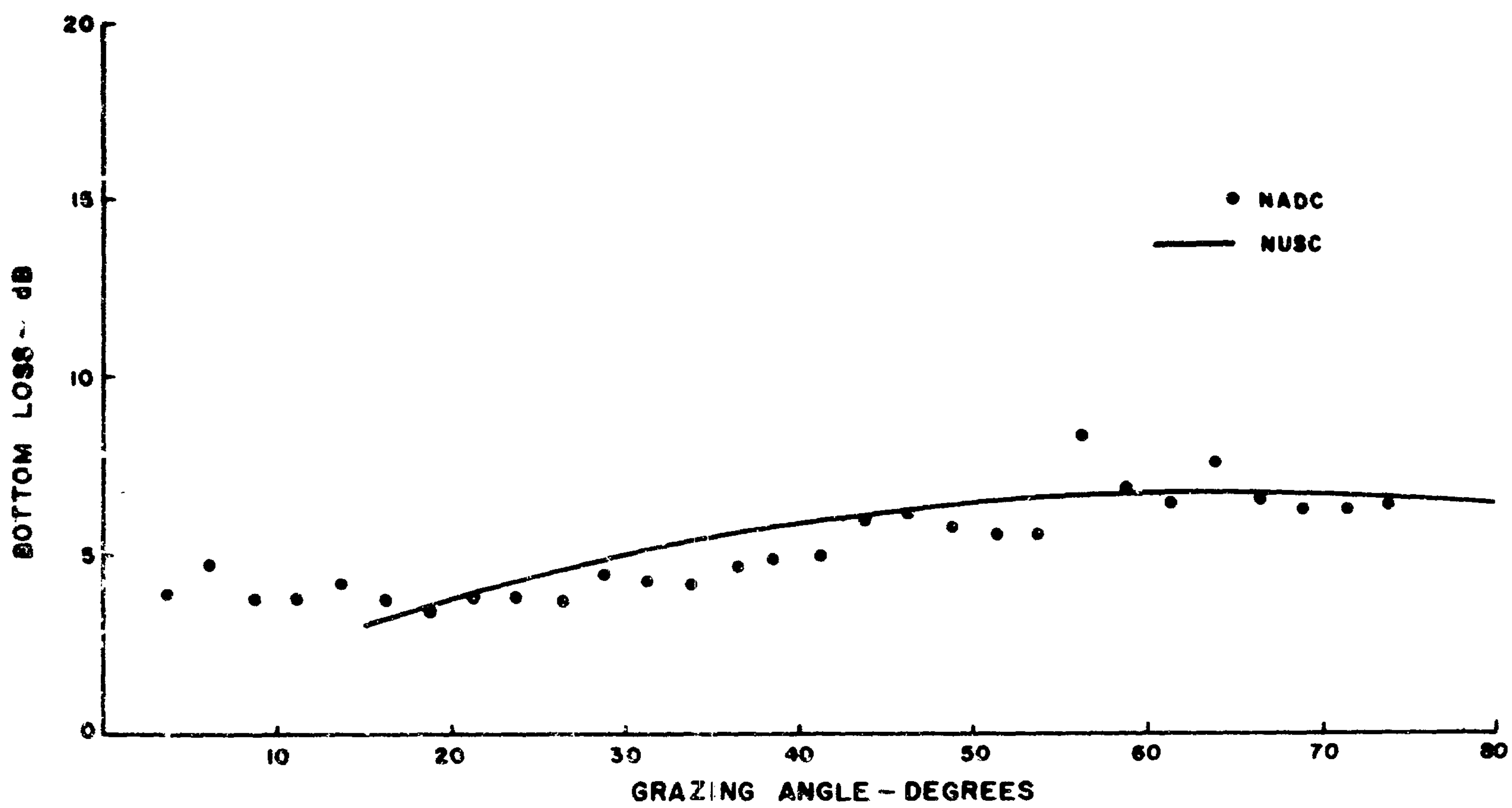
	Start Location		
Station	Lat.	Long.	Track
2001	25°26'N	157°44'W	355°
2002	26°36N	157°44'W	358°
2003	27°46'N	157°44'W	356°
2004	28°54'N	157°44'W	002°
2005	29°22'N	158°40'W	155°
2006	28°19'N	158°08'W	155°
2007	26°50'N	160°01'W	69°
2008	27°15'N	158°45'W	70°
2009	27°38'N	157°32'W	70°
2010	28°01'N	156°21'W	70°

(C) TABLE XXIII

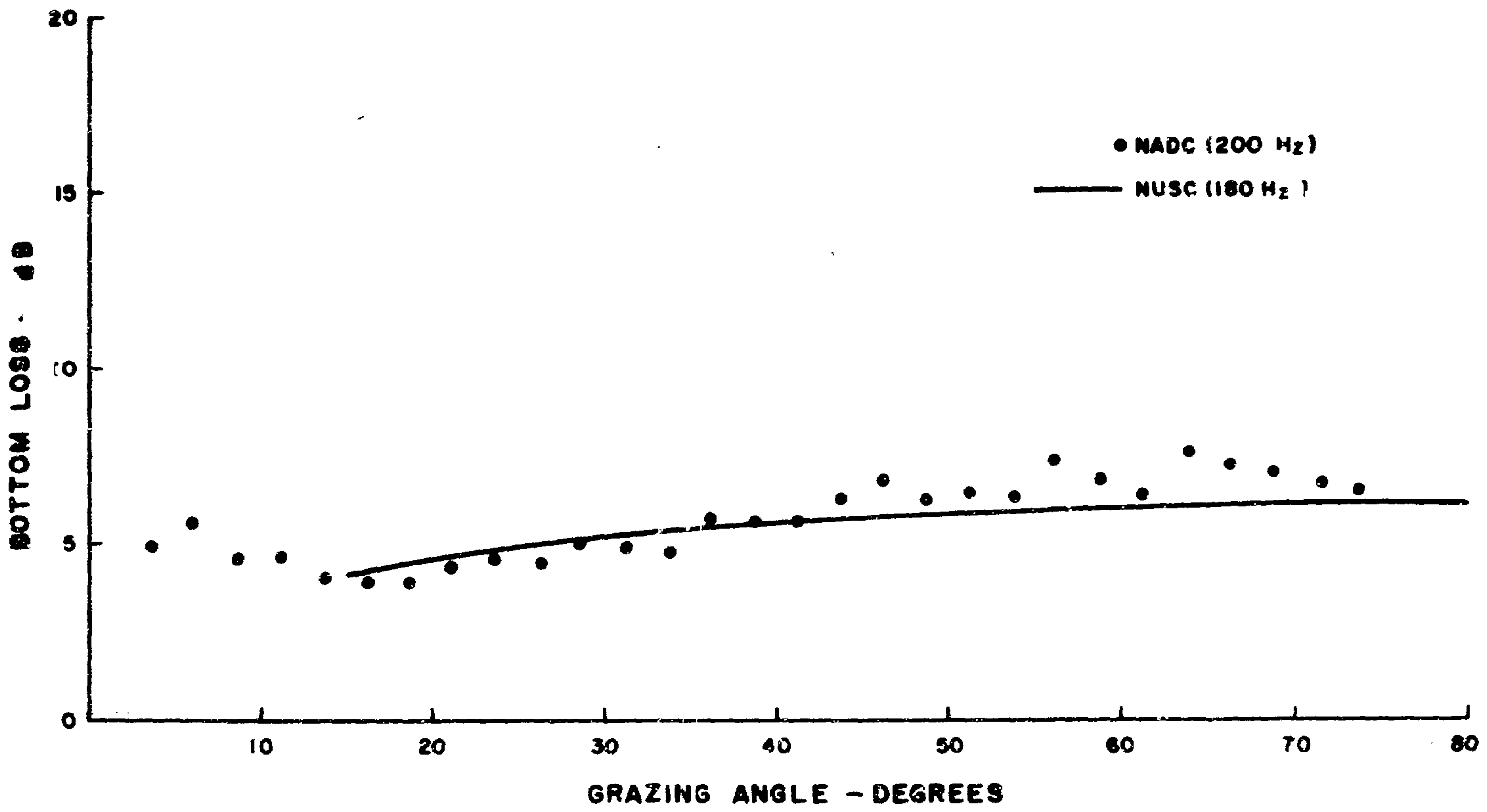
COMPARISON OF NAVAIRDEVCEN AND NUSC

BOTTOM LOSS MEASUREMENT AND PROCESSING METHODS (U)

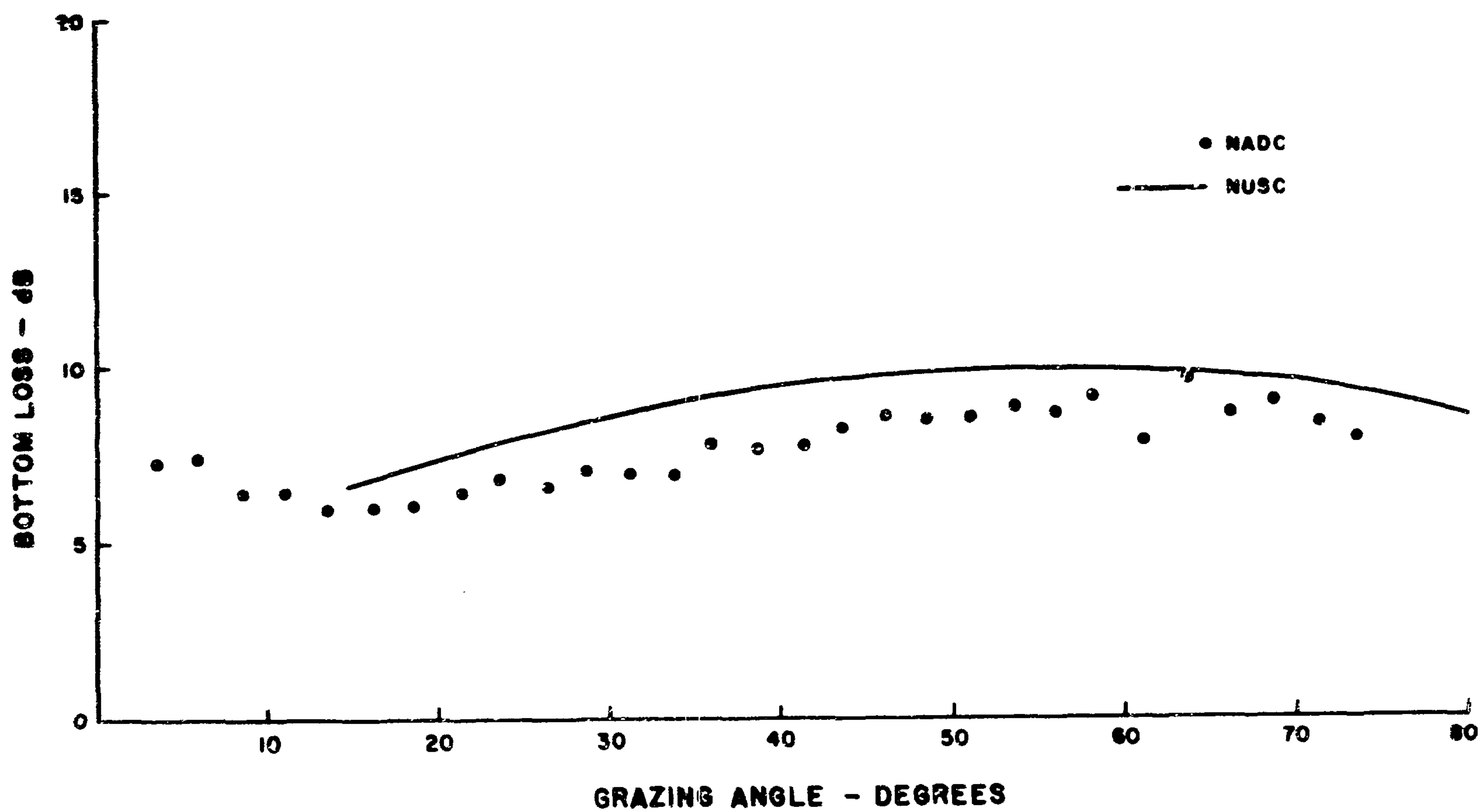
	NUSC	NAVAIRDEVCEN
Platform	Shooting/receiving ships	Single aircraft
Acoustic source	3 lb TNT at 500 ft	1.8 lb TNT (SUS) at 800 ft
Acoustic receiver	Ship-suspended hydrophone, 11,000 ft	Modified Q-57A sonobuoys, 300 ft
Shot spacing	Constant grazing angle increm: 2 degrees above 30 degrees, 1 degree between 15 and 30 degrees	Constant range increm: nominal 3.7 kyd from 4 to 100 kyd
Bounce modes	1	1, 2, 3
Source level	"Self-cal," direct path measurement	Literature
Processing bandwidth	1/3-octave	1-octave
Bottom loss averaging	Polynomial curve fit	Medians in 2.5 degree grazing angle intervals
Data points at PARKA site	100	700



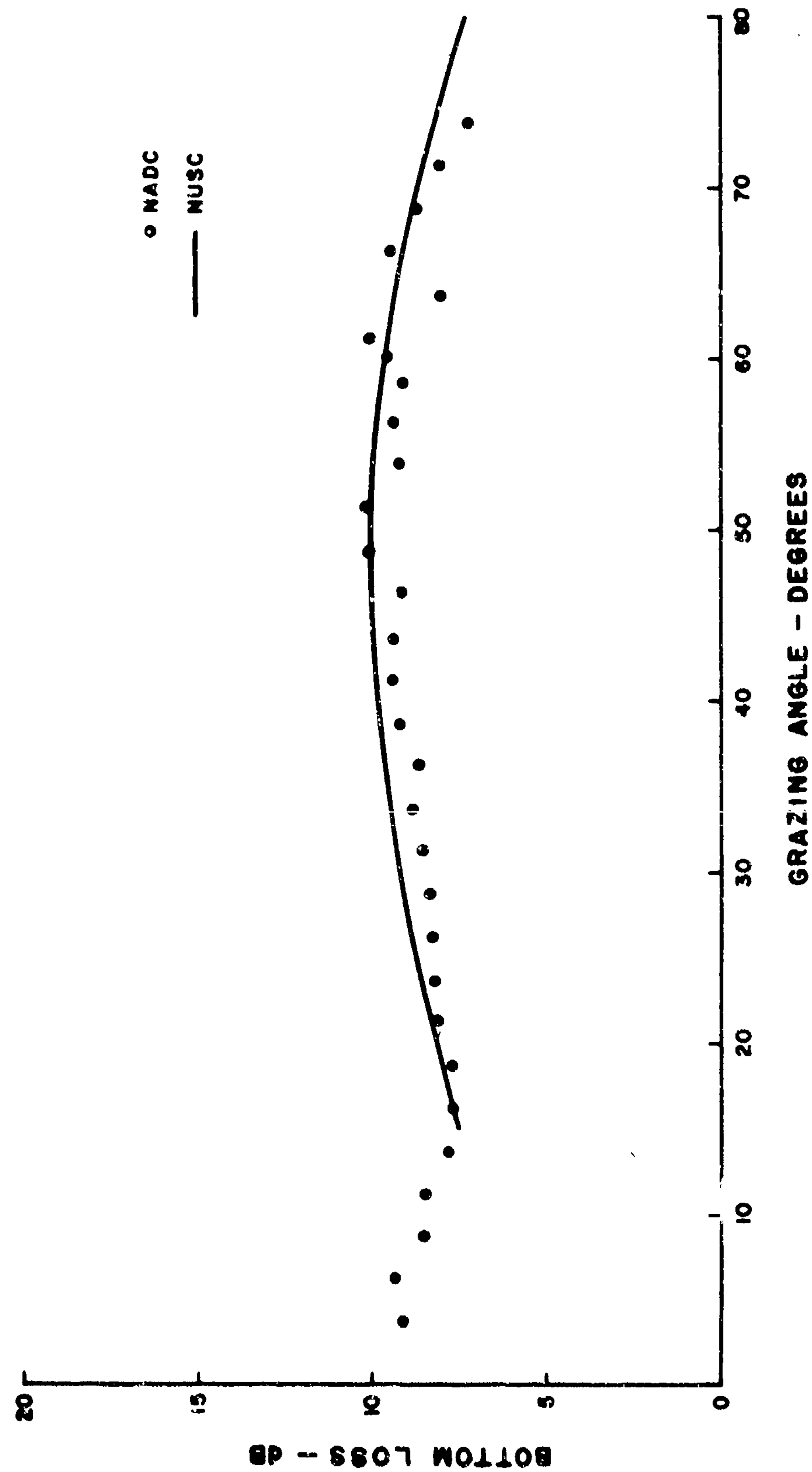
(C) Figure 29 - Comparison of NAVAIRDEVCEN and NUSC Bottom Loss Results from PARKA Site: 100 Hz. (U)



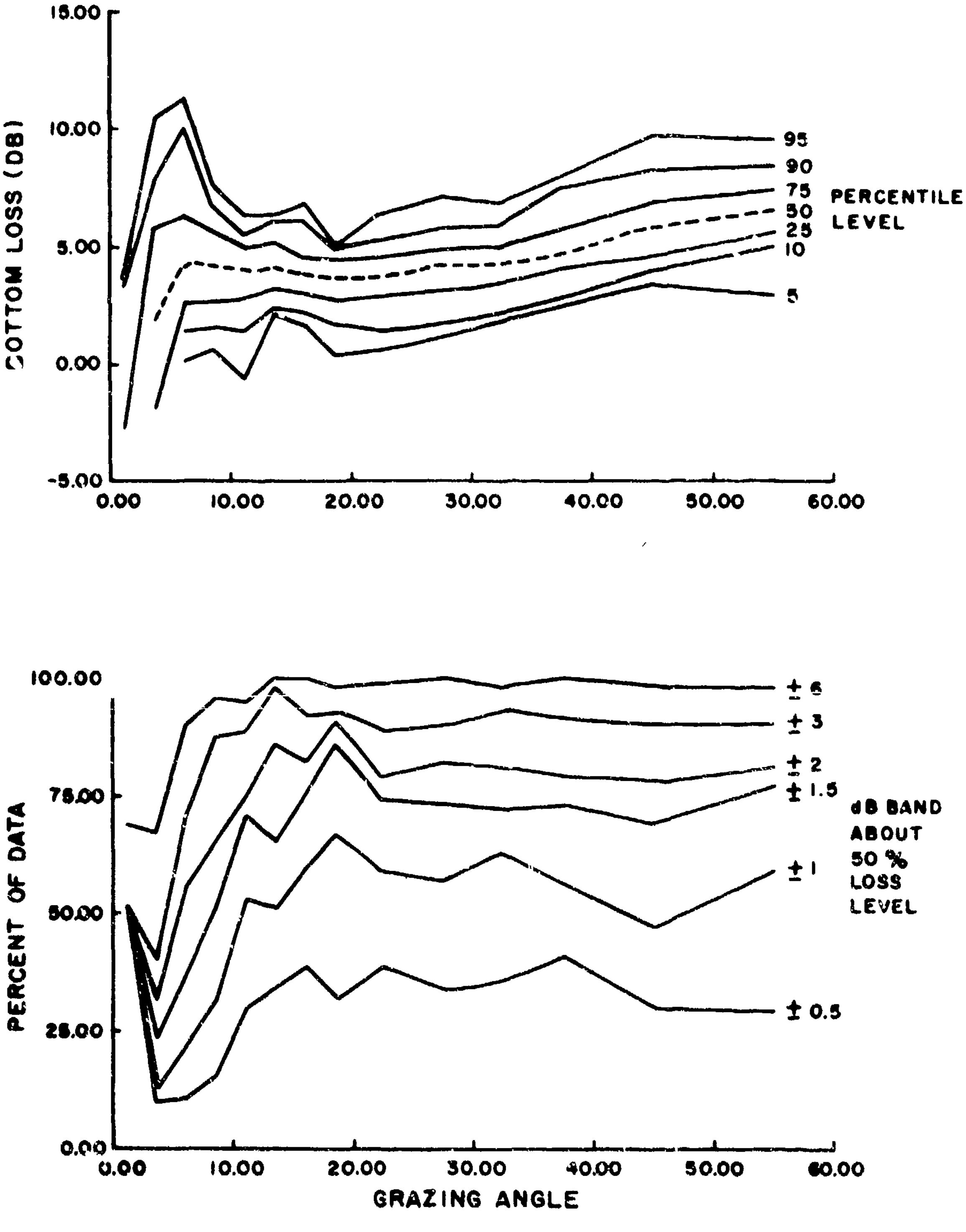
(C) Figure 30 - Comparison of NAVAIRDEVCEN and NUSC Bottom Loss Results from PARKA Site: 180/200 Hz. (U)



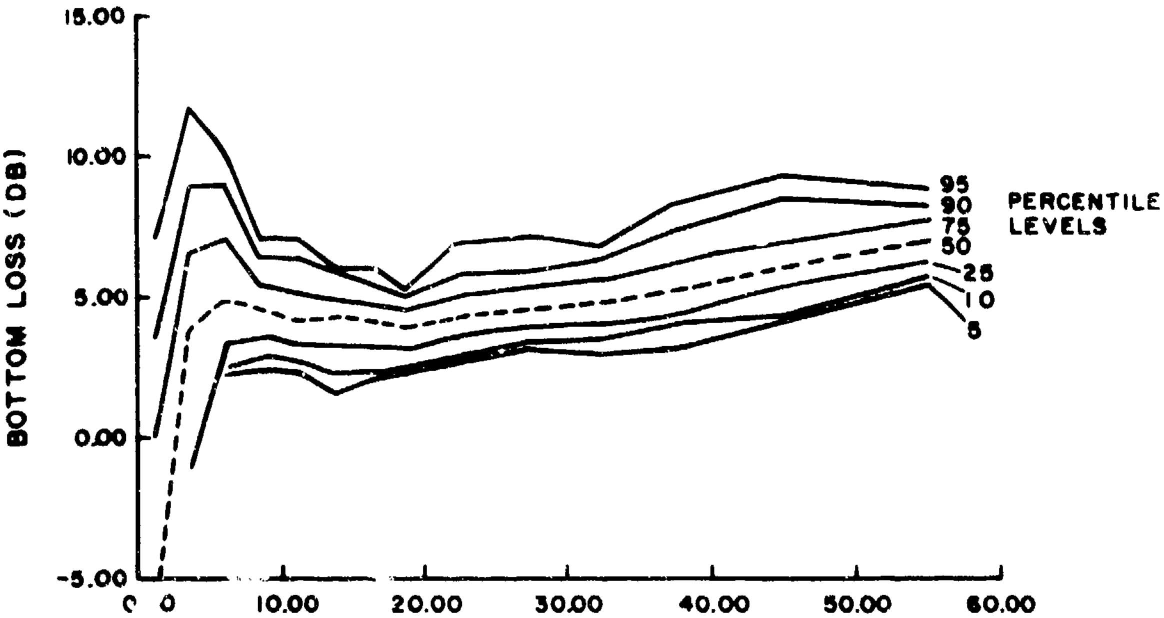
(C) Figure 31 - Comparison of NAVAIRDEVCEN and NUSC Bottom Loss Results from PARKA Site: 400 Hz. (U)

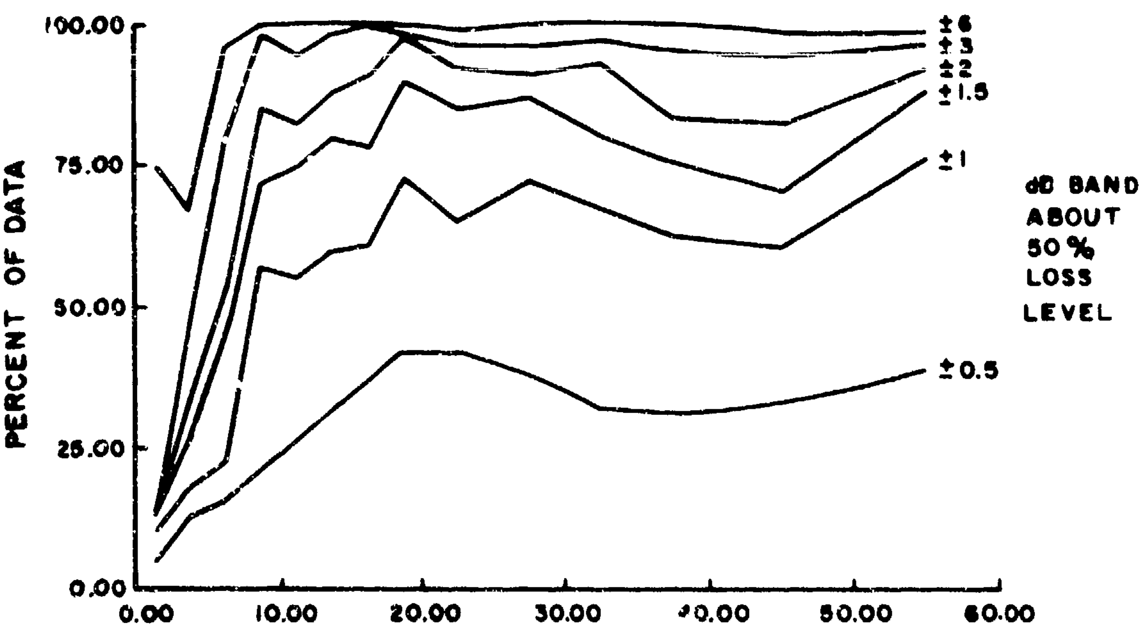


(C) Figure 32 - Comparison of NAVAIRDEVCEN and NUSC Bottom Loss Results from PARKA Site: 800 Hz. (U)

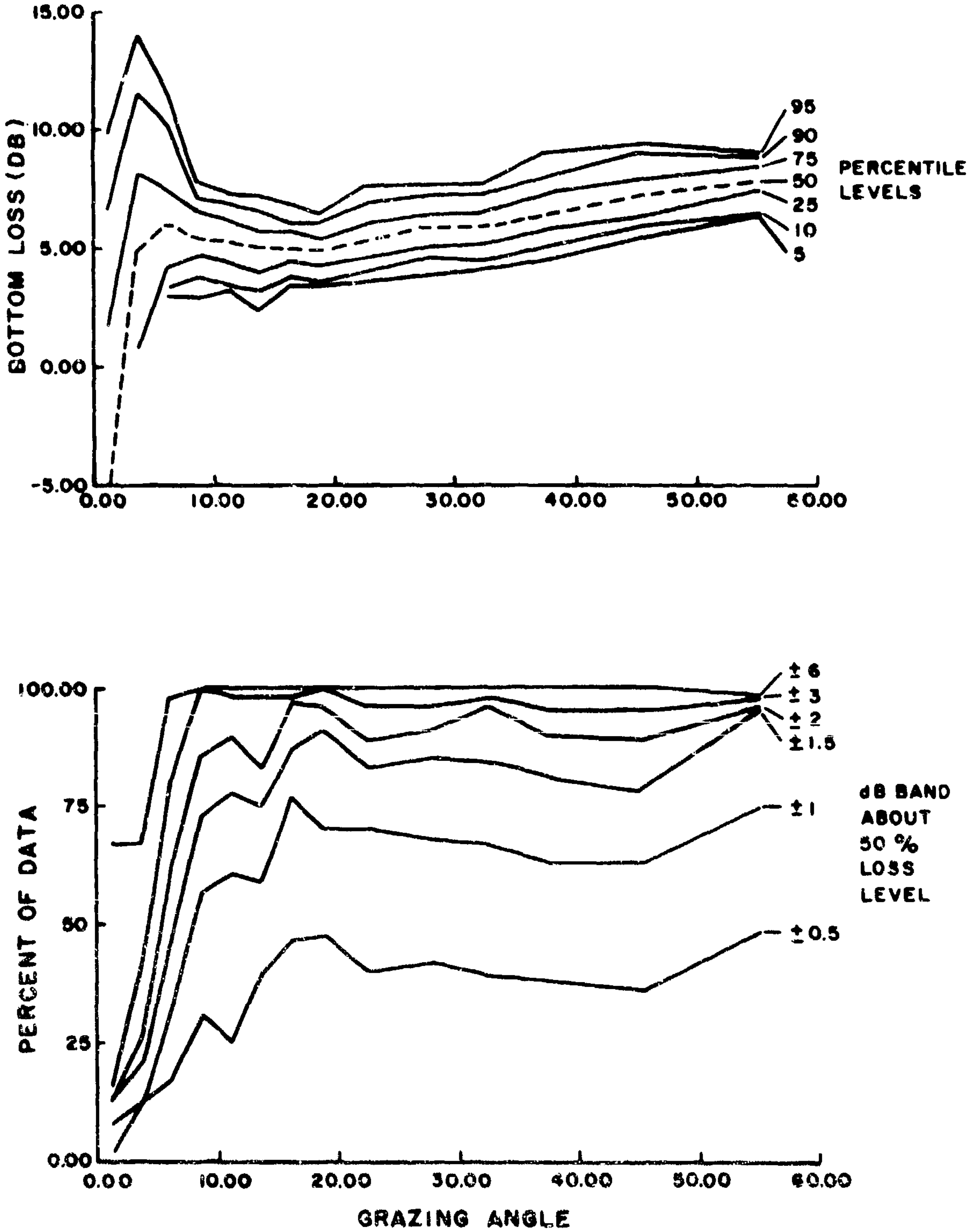


(C) Figure 33 - PARKA Site Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 100 Hz octave. (U)

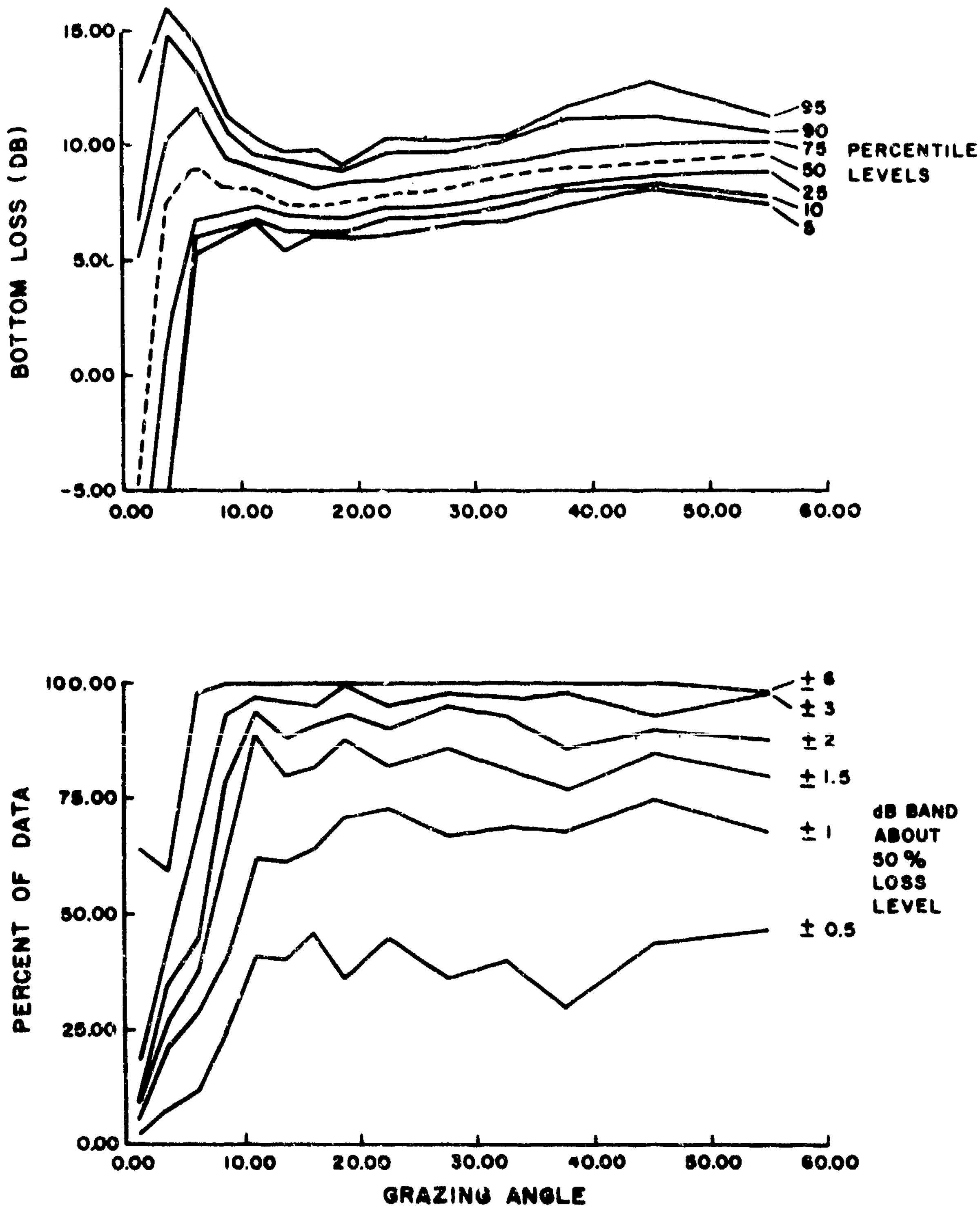




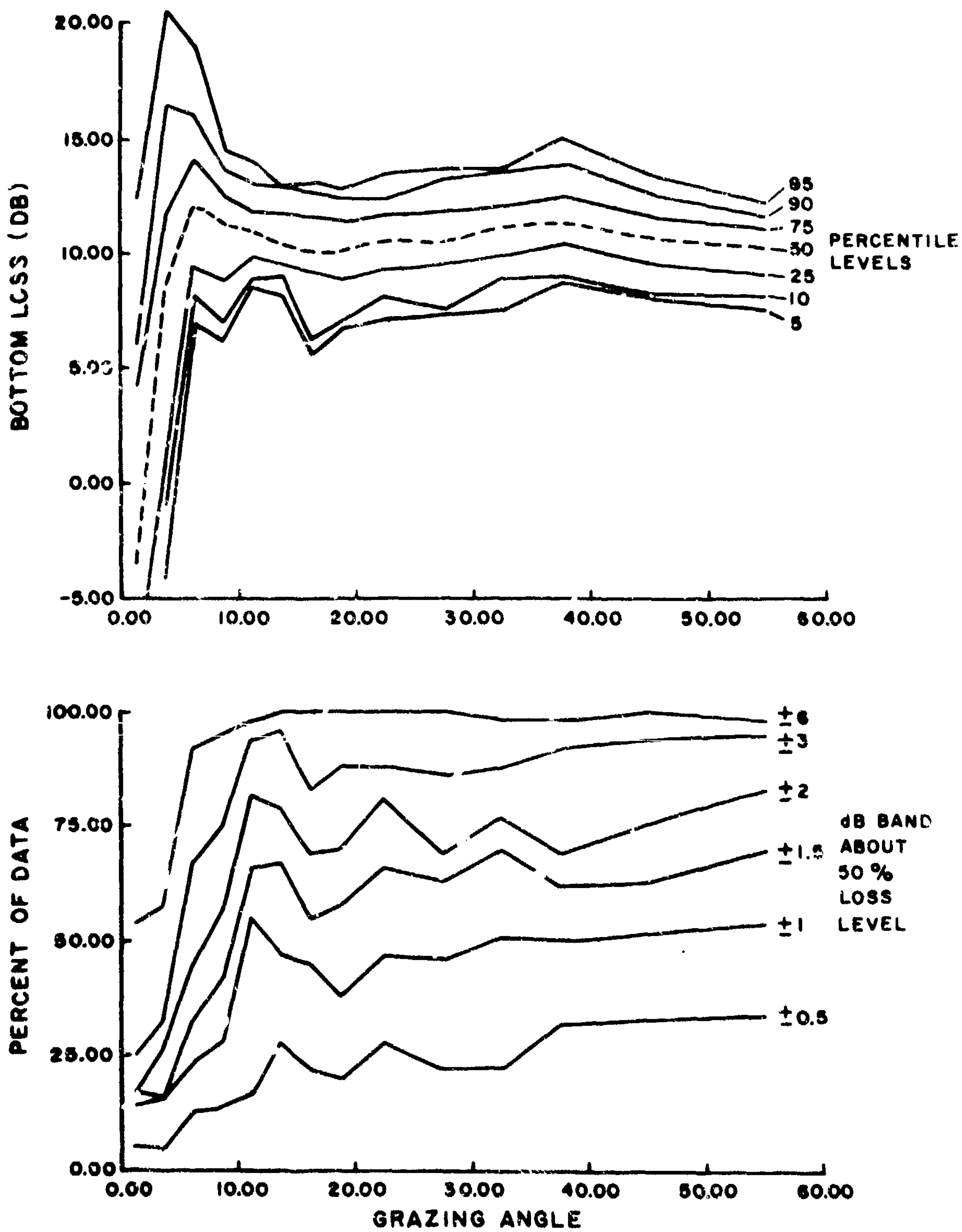
(C) Figure 34 - PARKA Site Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 200 Hz octave. (U)



(C) Figure 35 - PARKA Site Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 400 Hz octave. (U)



(C) Figure 36 - PARKA Site Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 800 Hz octave. (U)



(C) Figure 37 - PARKA Site Bottom Loss at Various Percentile Levels (a) and Percentage of Data within Various Constant - dB Bands (b) as a Function of Grazing Angle: 1600 Hz octave. (U)

REFERENCES

1. Frazer, J. Z., et al, March 1972; Surface Sediments and Topography of the North Pacific; Scripps Institution of Oceanography.

2. Ewing, M., et al; Isopach Map of the Pacific; Lamont-Doherty Geological Observatory.

3. Christensen, R. E. and Geddes, W. H., September 1975; Refraction of Sound in the Sea Floor; U.S. Naval Oceanographic Office TN-3440-6-75.

4. Santaniello, S. R. and van der Veen, S. R., 29 June 1970; PARKA II-A Bottom Loss Measurements (U); Naval Underwater Sound Laboratory, New London, Tech Memo 2211-023-70; Confidential.

5. Smith, D. J. and Haas, P. S., 26 April 1974; Measurements of Low Frequency Bottom Loss at 100 North Atlantic Sites (U); NAVAIRDEVCEN Report No. NADC-74064-20; Confidential.

6. Christian, E. A.; "Source Levels for Deep Underwater Explosives"; Journal of the Acoustical Society of America, Vol 42, p. 905-907.

7. Bathymetric Atlas of the Pacific Ocean; U.S. Hydrographic Office publication numbers 1302 and 1303.

8. Horn, D. R., et al, 1968; Sonic Properties of Deep Sea Cores from the North Pacific Basin and their Bearing on the Acoustic Properties of the North Pacific; Lamont Geological Observatory.

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Subj: DECLASSIFICATION OF PARKA I AND PARKA II REPORTS

Ref: (a) CNMOC ltr 3140 Ser 5/110 of 12 Aug 97

Encl: (1) Listing of Known Classified PARKA Reports

1. In response to reference (a), the Chief of Naval Operations (N874) has reviewed a number of Pacific Acoustic Research Kaneohe-Alaska (PARKA) Experiment documents and has determined that all PARKA I and PARKA II reports may be declassified and marked as follows:

Classification changed to UNCLASSIFIED by authority of Chief of Naval Research letter Ser 93/160, 10 Mar 99.

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3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

Peggy Lambert

PEGGY LAMBERT
By direction

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Continuation of LRAPP Final Report, February 1972, Contract N00014-71-C-0088, Bell Telephone Labs, Unknown # of pages
(NUSC NL Accession # 057708)

PARKA II-A, The Oceanographic Measurements, February 1972, MC Report 006, Volume 2, Maury Center for Ocean Science (ONR), 89 pages
(NUSC NL Accession # 059194) (NRL SSC Accession # 85007063)

Project Pacific Sea Spider - Technology Used in Developing A Deep-Ocean Ultrastable Platform, 12 April 1974, ONR-ACR-196, 55 pages
(DTIC # **529 945**)

LRAPP Program Review at the New London Laboratory, Naval Underwater Systems Center, 24 April 1975, NUSC-TD-4943, Unknown # of pages
(NUSC NL Accession # 004943)

An Analysis of PARKA IIA Data Using the AESD Parabolic Equation Model, December 1975, AESD Technical Note TN-75-09, Acoustic Environmental Support Detachment (ONR), 53 pages
(NRL SSC Accession # 85004613)

Bottom Loss Measurements in the Eastern Pacific Ocean, 26 January 1977, NADC-76320-20, 66 pages
(DTIC # **C009 224**)

PARKA I Oceanographic Data Compendium, November 1978, NORDA-TN-25, 579 pages
(DTIC # **B115 967**)

Sonar Surveillance Through A North Pacific Ocean Front, June 1981, NOSC-TR-682, 18 pages
(DTIC # **C026 529**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1, Model Evaluation Methodology and Implementation, September 1982, NORDA-33-VOL-1, 46 pages
(DTIC # **C034 016**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1A, Summary of Range Independent Environment Acoustic Propagation Data Sets, September 1982, NORDA-34-VOL-1A, 482 pages
(DTIC # **C034 017**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 1, September 1982, NORDA-35-VOL-2-BK-1, 179 pages
(DTIC # **C034 018**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 2, Appendices A-D, September 1982, NORDA-35-VOL-2-BK-2, 318 pages
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